

$1.5x + 0.06 = \frac{1}{x}$
 $1.5x^2 + 0.06x = 1$
 $1.5x^2 + 0.06x - 1 = 0$
 $a = 1.5, b = 0.06, c = -1$
 $x = \frac{-0.06 \pm \sqrt{0.06^2 - 4(1.5)(-1)}}{2(1.5)}$
 $x = \frac{-0.06 \pm \sqrt{0.0036 + 6}}{3}$
 $x = \frac{-0.06 \pm \sqrt{6.0036}}{3}$
 $x = \frac{-0.06 \pm 2.4503}{3}$
 $x = \frac{-0.06 + 2.4503}{3} = 0.78$
 $x = \frac{-0.06 - 2.4503}{3} = -0.8167$

$1.5x + y = 3$
 $7x - 2y = 2$
From 1, $y = 3 - 1.5x$
Substituting in 2:
 $7x - 2(3 - 1.5x) = 2$
 $7x - 6 + 3x = 2$
 $10x - 6 = 2$
 $10x = 8$
 $x = 0.8$
 $y = 3 - 1.5(0.8) = 1.8$



MURK SUMMER 2011

MOUNTAINEER UNDERGRADUATE RESEARCH REVIEW

Volume 3, Summer 2011 — Published under the auspices of the West Virginia University Honors College in Morgantown, West Virginia.

The Mountaineer Undergraduate Research Review (MURR) publishes outstanding research performed by undergraduates at colleges and universities throughout West Virginia. MURR is a publication of the West Virginia University Honors College, and its initial publication was sponsored by West Virginia Experimental Program to Stimulate Competitive Research (WV EPSCoR). MURR is published on the Honors College website (www.honors.wvu.edu). Papers are reviewed by qualified faculty members at WVU, and reviewed and edited by a managing staff composed of WVU undergraduate students. Questions about the Mountaineer Undergraduate Research Review should be submitted to:

Lisa DeFrank-Cole, Ed. D., Director
ASPIRE Office
Honors College
109-A Honors Hall
250 2nd Street
West Virginia University
Morgantown, WV 26506
Phone: (304) 293-2100
Email: Lisa.DeFrank-Cole@mail.wvu.edu
Website: leadershipstudies.wvu.edu / aspire.wvu.edu

Managing Staff:

Lea Bridi, Editor-in-Chief
Caroline Miskovsky, Managing Editor
Dwight Pavlovic, Contributing Editor

Faculty Advisors:

Dr. Lisa DeFrank-Cole, Supervisor
Dr. Keith Garbutt, Dean of the Honors College

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Acknowledgments

First and foremost, MURR owes its existence to the inquisitive undergraduate students of West Virginia who choose to share their research, and to the faculty mentors who guide and encourage them. Additionally, MURR would not be possible without the aid of the Honors College and faculty advisors Dr. Lisa DeFrank-Cole and Dr. Keith Garbutt. Finally, the managing staff of MURR would like to thank the faculty reviewers who gave their time and expertise to our reviewing process: Dr. Tabitha Chigwada, Dr. Kasi Jackson, Dr. Elisa Krackow, Dr. Ken Blemings, Dr. Donley Studlar, Dr. Jack Hammersmith, Dr. Kenneth Fones-Wolf, Dr. James Siekmeier, Dr. Letha Sooter, Dr. Rosemary Hathaway, Dr. Robin Hissam, Dr. Elizabeth Kyonka, Dr. Scott Crichlow, Dr. Elizabeth Fones-Wolf, Dr. Evan Widlers, Dr. Mark Tauger, and Dr. Robert Blobaum.

From the Editor

MURR has grown considerably over the past three years. We received a record number of submissions for the Summer 2011 issue and are, in turn, publishing a record number of articles. We have also expanded the reach of our call for papers beyond WVU, inviting any undergraduate student performing research at a college or university in West Virginia to submit their work. We are happy to be publishing an article authored by a student from West Virginia Wesleyan College alongside those authored by WVU students. Because the expansion MURR has experienced indicates a growing interest in research among undergraduate students in West Virginia, I hope that MURR continues to grow and expand, in terms of both the numbers of submissions it receives and the diversity of colleges and universities from which articles are selected for publication.

Lea Bridi, Editor-in-Chief

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HUMANITIES & SOCIAL SCIENCES

COERCED AND GLORIFIED: FEMALE PALESTINIAN SUICIDE BOMBERS

Anna-Claire Bowers

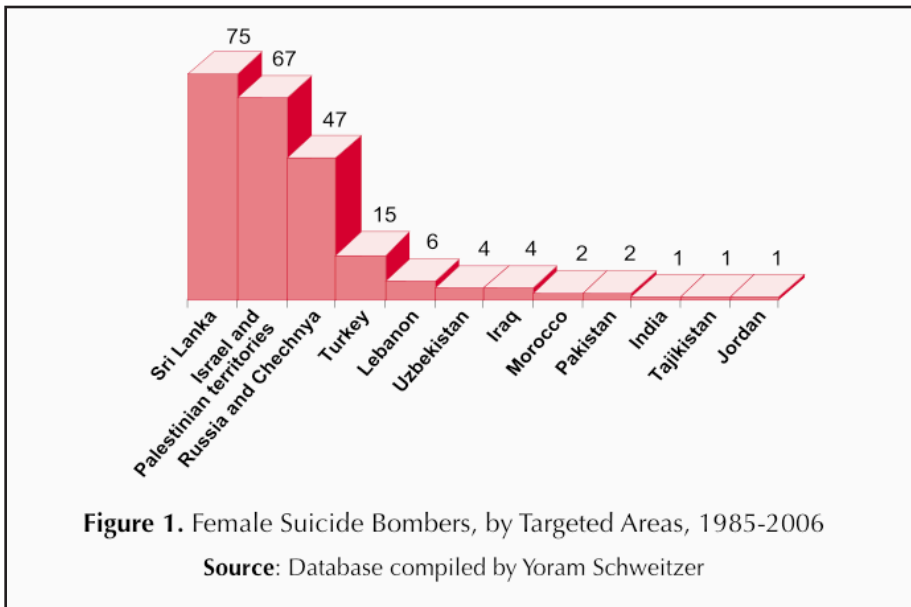
Introduction

Terrorism is loosely defined as acts of violence, which are intended to invoke fear into the population, are perpetrated with a political, ideological, or religious goal, and are committed by nongovernmental organizations, which target or disregard civilian casualties. For these contemporary terrorist organizations, suicide bombers are today's weapon of choice in comparison with traditional armed methods and guerrilla tactics. Suicide bombers are now used by 17 terror organizations in 14 countries in order to obtain various political goals (Schweitzer 2006, 14). The institute for Counter-Terrorism defined suicide bombing as an "operational method in which the very act of the attack is dependent upon the death of the perpetrator" (Zedalis 2009, 2). The term "suicide bomber" carries heavy emotional weight, as some emphasize the murder and terror produced from this act, while others glorify them as martyrs.

Terrorist organizations are increasingly using suicide bombers because they are cheap, low risk, and do not require sophisticated technology. These weapons are also widely available, require little training, and effectively instill fear into the general population. In terms of casualties, suicide bombers are presently one of the most efficient forms of terrorism. "From 1980 to 2001, suicide attacks accounted for 3 percent of terrorist incidents but caused half of the total deaths due to terrorism—even if one excludes the unusually large number of fatalities of 9/11" (Pape 2003). The effectiveness of this weapon is dependent upon the element of surprise and accessibility of their targets; this requirement has recently been met using women who escape the stereotyped profile of a suicide bomber. Female suicide bombers have been used in a variety of venues, countries, and terrorist organizations, including developing states such as India, Turkey, Palestine, Chechnya, and Sri Lanka (Zedalis 2009, 13). Comprehending the use of women as suicide bombers is crucial for informing security studies to include women, who might otherwise have been ignored. Therefore, the development of female suicide bombers demands careful study of this strategic weapon through the analysis of bomber characteristics and motivations, specific examination of recent cases, and how these women are portrayed in the media. This study argues that female suicide bombers are used as a tactical weapon and are frequently forced to commit these acts of violence through religious and political rhetoric as well as patriarchal norms.

Female Suicide Bombers in the Context of Global Developing States

The history of female suicide bombing is relatively new. One of the first attacks occurred in 1985, when a sixteen year-old Palestinian girl drove a truck into an Israeli checkpoint. Since then, women in Lebanon, Sri Lanka, Chechnya, Israel, and Turkey have strapped massive explosives to their bodies, carried bombs, and driven bomb laden vehicles in order to complete acts of terrorism (see Figure 1). Many organizations known for terrorist activity, such as the Syrian Socialist Party, Liberation Tigers of Tamil Eelam, The Kurdistan Workers National Party, Chechen rebels, Al Aqs Martyrs, and most recently, Hamas, have publicized female suicide bombers in order to gain attention for their causes (Whaley Eager 2008, 171). The method of suicide bombing has proven to be so unnerving and effective that its use has spread among many different groups, specifically, in the Middle East. Palestinian suicide bombers have carried out a large portion of the more recent attacks; in 2002 the first Palestinian female suicide bomber, Wafa Idris, detonated a twenty-two pound body bomb in an Israeli shopping district (Zedalis 2009, 17).



Understanding why are female suicide bombers used is a question critical to understanding the phenomenon of female suicide bombers. Globally, there are over twenty-three terrorist organizations that use women as weapons for a number of reasons (ORourke 2009, 681). Mostly, they provide a strategic advantage. There is a hesitancy to search women and females because they are stereotyped as pacifists, which can lead to more successful attacks. They also provide an increased number of combatants as well as publicity, which can produce a larger number of recruits overall. The additional media attention resulting from their attacks encourages terrorist organizations to capitalize on their sensationalism. Such terrorist groups believe that suicide bombers have the ability to bring notice to their political cause and contend that suicide bombers are the only effective means of weapons they have, in contrast to their enemies' overwhelming military and

financial strength. The psychological effect of terrorism on the population at large holds significant weight as well, as it adds an increased sense of vulnerability and desperation. Middle Eastern scholars have theorized that the use of Palestinian militant groups is specifically designed to embarrass the Israeli regime and show that the situation is desperate enough that women are fighting instead of the men. This idea could be applied to the Black Widows in Chechnya; these combatants are an all-female terrorist group that organizes politically motivated attacks on Russia (Spekhard, Ahkmedova 2006, 63).

Who becomes a suicide bomber is an elusive and complicated question for both males and females. There are some definite trends suggested, but these are also highly disputed, while others maintain that a rigid profile is impossible to develop. Factors assessed in order to create a profile include age, education, economic standing, and socialization toward violence. The only factor that is an accurate indicator is age; virtually all suicide bombers tend to be young people (see Figure 2). The average age varies from 21.5 (Turkey) to 23 (Lebanon), a small differential. Additionally, education appears to play a role as “the percentage increases with the level of education: 8.3 percent among elementary school diploma versus 12.8 percent among those with a university degree” (Zedalis 2009, 14). This finding is particularly interesting and frightening as it might be assumed that the inverse is true (see figure 3).

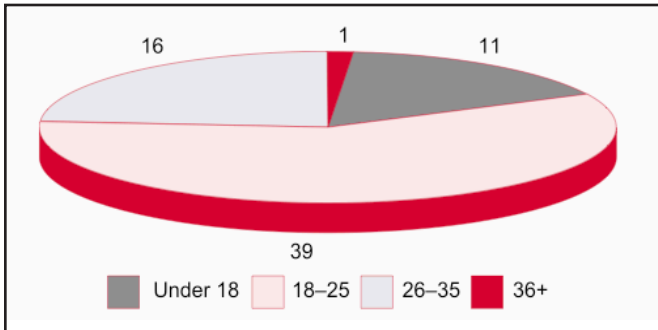


Figure 2, Female Suicide Terrorists: Breakdown by Age (Yoram Schweitzer)

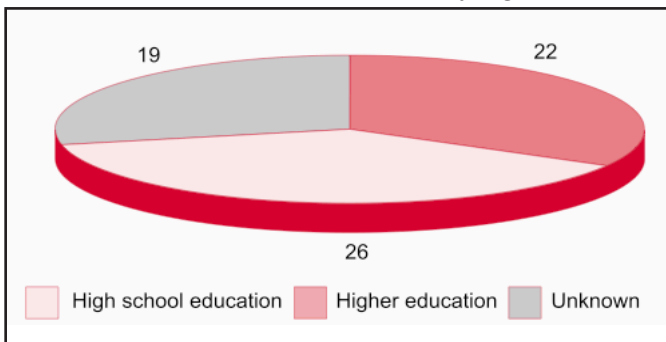


Figure 3, Female Suicide Terrorists: Education Level (Yoram Schweitzer)

Women’s participation in terrorist attacks vary widely, and it is difficult to generalize simply because of its small sample size and limited research completed on the subject. Despite limited data, female suicide bombers, just like their

male counterparts, have one factor in common: they are almost all young (see figure 2). Other characteristics do not seem to produce causation; there are mothers, widows, highly educated professionals, and both impoverished and middle class women who participate in these violent acts. Many analysts have compared the Black Widows in Chechnya to the Palestinian suicide bombers, as some scholars have characterized these conflicts as politically motivated struggles for national identity paired with religious overtones (Spekhard and Akhmedova 2006, 68).

Analysts and scholars have tried to look for the motivations to become a suicide bomber, and can point to numerous religious, nationalistic, economic, and social rewards. Researchers have also concluded that the motivations for women and men carrying out a suicide attack are frequently the same. They are committed, patriotic believers, and this is frequently combined with a sense of religious duty. Religious terrorism is particularly powerful as a religious component offers justification for violent atrocities and otherwise immoral acts. Many suicide bombers see their actions as dictated by a higher power that will reward them in the afterlife. This Muslim idea dictates that the after-life of every martyr will be greeted with purification of all sins and all the pleasures of God's graces (Yadlin 2006, 52).

In addition to religious and political motivations, suicide bombers may be motivated economically by the monetary rewards given to their family. Besides the clear economic incentive, a son or daughter who becomes a martyr may enhance the family's social status and reputation. After their death, suicide bombers are frequently heroically glorified, invoking a culture of martyrdom while increasing recruitment. Many organizations are now deliberately targeting women for recruitment as female suicide bombers receive much greater attention from the media. In this way, the media becomes both an advertising and recruitment tool for terrorist groups, as the public perception of terrorism is frequently determined by the degree of media coverage, not the level of violence. Counter terrorism experts are concerned that if women continue to follow suit, it will attract disproportionate publicity; this trend may create worldwide sympathy for suicide bombers, and serve as a terrorist recruitment tool (Alvanou 2006, 91).

In reviewing the literature surrounding female suicide bombers, it is clear that who and why someone becomes a suicide bomber are complex, indefinite questions. Regardless, it is unmistakable that women are being used as a tactic to evade security measures and increase recruitment. These women are often forced into committing such acts due to a wide variety of factors: religious pressures, economic incentives, and gender norms existing in their societies. Studying female terrorism is becoming increasingly important as security measures and cultural perspectives must be adjusted to include women. The case of the Palestinian-Israeli conflict is representative of the phenomenon, as it provides clear examples of women being coerced into choosing violence and being used as a tool to increase recruitment for suicide bombing. It also offers an opportunity to study female suicide terrorism in the context of an ongoing conflict, which is increasingly utilizing females as terrorists within a patriarchal, Islamic society.

Palestinian Female Suicide Bombers

The Palestinian-Israeli conflict is an emotionally charged one for many peoples of the region and is often associated with religious violence. Palestinian women have played a distinct role in the conflict as mothers and most recently, as suicide bombers themselves. During the first Palestinian *intifada* (uprising) against Israel, in 1987, women were called upon by the leaders of the Palestinian national movement to play a traditional female role as mothers of the nation. Muslim women's role in the struggle for liberation was not to participate in the actual resistance, but to produce the men who would become suicide bombers and jihadists. This discourse transformed Palestinian women's fertility into a nationalist patriotic subject. However, the most recent *intifada* in 2000 differed through "a gender-oriented social agenda as an alternative to the national agenda of the hegemonic male leadership; an alternative motherhood, along with the previous recruited national motherhood; and the phenomenon of women suicide bombers" (Shweitzer 2006, 7). The appearance of women taking an active, violent role in the conflict was both glorified and demonized in the media, but both their roles as mothers of the jihad and as suicide bombers themselves has only preserved traditional gender roles (Tzoreff 2006, 14).

Wafa Idris blew herself up on a main street in Jerusalem on January 27, 2002 and Al Aqsa Martyrs Brigade claimed responsibility for the first *shahida*. Wafa was born in a refugee camp in 1975 and was married to her first cousin at the age of sixteen. Unable to carry a pregnancy to term, patriarchal norms devalued her position in life due to her inability to have children. Wafa later became a volunteer for the Red Crescent, experiencing atrocities that supposedly deeply haunted her. Although much speculation exists about her ideological motivations, testimony from her friends and family suggest she committed the act for personal reasons. Wafa was twenty-five, divorced by her husband, barren, and had become an economic burden on her parents' home. Although her friends admit she was disturbed by the terrible actions she witnessed committed toward Palestinians by Israelis, they speculate her act was due to the failure of her marriage (Whaley Eager 2008, 188-189). Wafa's suicide bombing was monumental, as it pioneered the path for other Palestinian women unable to meet society's expectations, such as Darin Abu-Aisha, a twenty-two year old student from a village near Nablus (Tzoreff 2006, 21).

Darine Abu-Aisha provides another case of a female suicide bomber forced into committing violence through societal pressures. A twenty year-old university student from a privileged background, Darine does not fit the profile of a stereotyped suicide bomber. According to interviews with her family, Darine was deeply humiliated at an Israeli checkpoint after being forced to kiss her male companion who she was not married to. After the incident she was seen as unmarriageable and completely disgraced in the community. Upon refusing to marry her companion with whom she had shared the humiliating experience, a male relative introduced her to Hamas leaders at the university Darine attended. Shortly afterward and with minimal training, Darine killed herself and wounded several Israelis at a checkpoint. The patriarchal, coercive methods driving Darine's attack are evident. Due to one degrading incident, Darine lacked a respectable future and turned to desperate violence with the direction of a male relative (Whaley Eager 2008, 188).

A third case, involving Reem Salih al-Rayasha, also depicts the coercion of Palestinian women to commit terrorist acts. Allegedly involved in an adulter-

ous affair, the twenty-two year old mother of two children detonated a bomb at a border checkpoint between Palestine and Israel, killing four Israeli soldiers. It is believed that marital problems initiated her adultery and her husband and lover both sent her on the suicide mission in order to avoid social sanctions she would have faced by the community at large. This case reinforces the idea that the inclusion of women in terrorist suicide bombings is not leading to greater equality or secularization in the Palestinian community. It only reaffirms their role as second-class, commoditized citizens.

Although it is clear that these women committed terrorist acts in desperation and as a result of marginalization, some scholars argue that this phenomenon represents a cultural shift. Not only was the phenomenon of Palestinian female suicide bombers unprecedented, it departed from generalized stereotypes of women. In societies where *sharia* (Islamic law) is used and in secular states as well, women are frequently perceived as more timid, modest, and responsible for the honor of the family based on the maintenance of their sexual purity. Such cultural and religious norms frequently confine women to the private sphere, and their traits may be perceived as a social and religious commandment internalized by women at large and harshly enforced by certain governments. The widespread response to female Palestinian suicide bombers committing terrorist attacks has been argued as a direct challenge to such entrenched social norms. Some scholars, such as Shibli Telhami of Maryland University and the Brookings Institute, have perceived the inclusion of female suicide bombers indicates a greater secularization of the phenomenon. Miriam Cooke of Duke University concluded that, "female martyrdom must be accounted for by a total despair of the Arab woman in the struggle to empower herself against the U.S., the old colonial forces, and her husband." Regardless, according to a 2003 article in the Washington Post, female suicide bombers are portrayed as marginalized and the desperate product of aberrant backgrounds and patriarchal ideals (Stern, 2003).

Despite the alleged secularization and feminization of the movement by some scholars, Palestinian female suicide bombers are not challenging societal roles and are largely coerced to perform such crimes due to patriarchal pressure (It is important to note that women are not in leadership positions in any of the organizations that have claimed responsibility for their attacks). Palestinian women are not the ideologues or organizers for Islamic or secular terrorist organizations, and their opinions are not a determining factor even in the suicide missions on which they are sent (Whaley Eager 2008, 194). Yoram Schweitzer has demonstrated this in his study of women within organizations practicing terrorist acts:

Examination reveals that despite their high profile, women play a marginal role in their organizations, both numerically and in the corporate structure (even if in some areas such as Turkey they comprised around 40 percent of all the suicide bombers, in Sri Lanka, 20-25 percent, and in Chechnya, 43 percent). They are definitely not the leaders in their organizations, but serve rather as pawns and sacrificial lambs. (Schweitzer 2006, 23)

Authors Mia Bloom and Barbara Victor have completed detailed analysis

on the suicide bomber problem. Both have argued that the inclusion of women is not a sign of gender equality (Shweitzer 2006, 25). Rather, they are often raped, sexually abused, and taken advantage of, and forced to commit terrorist acts. Women are portrayed in the media as supportive toward Palestinian nationalism, but the motivation to become a martyr is a distorted fulfillment of patriarchal ideas. Deborah Gavin encapsulates this viewpoint:

Female terrorism has no autonomy. It is part of a male engineered, male dominated activity and even the most ardent feminists must recognize both the fact and the remote likelihood of it changing. Terrorism is all about power. The male terrorist struggling for power is not about to share it with the female, though he welcomes her aid and actively seeks to co-opt it. (Whaley Eager 2008, 190)

Palestinian women such as Wafa, Darine, and Reem are frequently used by terrorist organizations to gain notoriety and greater attention in the media. Globally, female suicide bombers draw much more notice in the press than male suicide bombers. Palestinian terrorist organizations such as Al Aqsa Martyrs Brigade have used the media's increased interest in female suicide bombers to publicize their political motivations. After the attack by Wafa Idris, Egypt's weekly *Al Shabab* published an editorial exclaiming: "It's a Woman!" The editorial stated: "It is a woman who teaches you today a lesson in heroism, who teaches you the meaning of Jihad...It is a woman who has shocked the enemy with her thin meager and weak body" (Whaley Eager 2008, 190). The day that her bombing took place, posters instantly appeared of Wafa wearing a green headband saying: "Allah is the answer," while carrying an assault rifle (Whaley Eager 2008, 188). Although this could be marketed as feminist rhetoric, it still maintains that women are weak, meager, and thin, and their gender is inferior to men.

Israeli and Arab press have differed in their depictions of Palestinian female suicide bombers. Both sides have publicized competing versions of reality. Israeli media often perpetuates the chauvinism existing in Arab society by portraying the women in a sympathetic light in comparison with male suicide bombers. Israeli media judges men more harshly as economic and security issues are always a cause and concern, while social issues are rarely highlighted. This narrative portrays women as weak and easily manipulated by the men in their lives. In doing so, it focuses on personal motivations such as being divorced, raped, or barren instead of the potential political reasons for their actions. Although their personal motivations are important, it should not be completely divorced from the political (Issacharoff 2009, 43). A report in *Yediot Ahronot* stated:

This is how terrorist organizations recruit female suicide terrorists to commit suicide attacks: 'If you don't commit a suicide terrorist attack, we'll tell people you were raped.' Agents of Fatah and Tanzim in the Beit Lehem area rape young Palestinian women, or seduce them into having sexual relations. Then they blackmail them by telling them, 'Either you commit suicide attacks, or we'll tell your family.' These are reports obtained by IDF intelligence sources. (Issacharoff 2009, 44)

A local newspaper *Kol Hazman* also wrote about Wafa Idris, the first Palestinian female suicide terrorist, in a similar manner:

Her father died when she was eight years old. Her brother served ten years in an Israeli prison, and founded al-Aqsa Brigades in the al-Amri refugee camp. Her husband divorced her after she had a miscarriage in the seventh month of pregnancy, and two months ago, she refused to remarry. Is it possible that Wafa Idris, a paramedic in the Red Crescent, committed suicide this week on Jaffa Street mostly because her life was so miserable? (Issacharoff 2009, 44)

In contrast, the Arab media downplays social issues and develops the Islamic feminist dimension, portraying women as key players in the national and religious jihad of Palestine (Isacharoff 2009, 46). For Example, another Egyptian newspaper *Al-Ahkbar* wrote about Wafa Idris:

The body parts of the *shahida* outlined the change on the earth of the fatherland, and in the ideology of the struggle. Palestinian women have torn the gender classification out of their birth certificates, declaring that sacrifice for the Palestinian homeland would not be for men alone; on the contrary, all Palestinian women will write the history of the liberation with their blood, and will become time bombs in the face of the Israeli enemy. (Isacharoff 2009, 49)

However, this Islamic feminist perspective has faced criticism from religious and secular leaders who have publicized their feelings that motherhood is the real jihad for women. Regardless, both perspectives about women's involvement in the struggle for liberation do not reflect a reality of improved gender equality for Palestinian women. It only displays the coercive tactics used by religious militants and terrorist organizations through targeted discourse.

Consequently, what is special about female suicide bombers and why do they merit scholarly study? Firstly, using female suicide bombers is an extremely effective tactic.

Women arouse less suspicion and are better able to clear checkpoints and other security obstacles. In addition, they do not have to undergo special training or possess specialized combat skills, and therefore they offer an efficient use of human resources. Moreover, the fact that a woman attracts greater media attention is an asset in and of itself to the organization that sent her. (Shweitzer 2006, 22)

They offer an element of surprise required for a terrorist attack that is not provided by their male counterparts. Secondly, the gender-specific norms in nations, such as Palestine, are used by terrorist organizations to develop discourse that specifically targets women (ORourke 2009). The position of women in terrorist studies is dependent on the cultural, social, and religious standards, which place them in a different position than men. "They are 'special' deviants, not because the operational method of their self-immolation differs from that of men, but because their womanhood plays a key role in the way the whole social environment influences them" (Alavnou 2006, 96).

Recommendations

Security and counter-terrorism policies need to adjust and defend against the rising trend of female suicide terrorists. States like Israel, which are targeted by female suicide bombers, need to revise their policies to include and undermine women's advantages in achieving surprise and concealing their explosives. If such changes were made, female suicide bombers would be expected to decline. However, it is unlikely that more effective counterterrorism measures will be applied to women. Counterterrorism efforts geared toward women are usually extremely slow to develop and targeted states occupying a territory, such as Palestine, risk violent outbreaks if it is viewed they are trying to win loyalty from local women (ORourke 2009, 692). Additionally, religious groups using women as suicide bombers illustrate a willingness to develop further tactics to overcome security measures.

Terrorism expert Jessica Stern recently criticized the Department of Homeland Security for ignoring the potential threat of female terrorists: "The official profile of a typical terrorist-developed by the DHS to scrutinize visa applicants and resident aliens-applies only to men. Under a program put in place after September 11, 2001, males aged between 16-45 are subject to special scrutiny; women are not." Counter terrorism strategies nationwide and internationally should not rely on profiling based on gender or race, as this practice puts both Americans and citizens of other nations at risk. A comprehensive counterterrorism plan should recognize the increasing potential for use of suicide bombers, including females. A female suicide bomber representing Al Qaeda has yet to act, but in March 2003 this information was uncovered in an interview:

Asharq Al-Awsat, leader of the female mujahedeen of Al Qaeda, told them her instructions came from Al Qaeda and the Taliban, mainly via internet...The woman went on to state that the organization was planning "a new attack which would make the United States forget September 11, and that the idea came from the martyr operations carried out by the Palestinian women. (Agence France Presse, 2003)

Due to their strategic advantage, it is likely that a terrorist organization like Al Qaeda will continue to use suicide bomber tactics and employ female suicide bombers. Global and domestic security policies must be adjusted to include the potential for female suicide bombers, as the safety of citizenry in the United States and worldwide depends upon it.

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WHAT COMIC BOOKS AND POLITICAL CARTOONS REVEAL ABOUT MEXICAN HISTORY

Carolyn Brewer

History and popular culture have played off one another for centuries. While comic books might certainly seem to be a low-class form of entertainment, lacking the authority of a history textbook, they nonetheless allow the readers to engage in history as they have otherwise never experienced it. Rather than reading descriptions of what happened when the Spanish landed in Mexico, one may read *The Cartoon History of the Modern World* or *Exploring the Americas* to see clothing of the time-period as well as how some of the historical characters may have felt. By using comic books and political cartoons, one can study historical views alongside societal ones. Since comic books and political cartoons generally reflect the time period in which they were written, these sources may serve as benchmarks to gauge societal opinions and views of history.

Although many people do not consider comic books as a viable, historical resource, they nonetheless present information relevant to the topic. Unlike textbooks, comic books are “accessible to even the poorest sectors of society” because comic books use a “combination of images and words, their colloquial language, and their simple language.”¹ By using common language and imagery that intertwines with the text, comic books present their own interpretation of history. The word for comic books in Mexico is *historietas* and, to non-Spanish speakers, looks similar to the word history.² However, the true meaning is found by looking closer at the context of comic books, a quick glance reveals stories of love, adventure, violence and power. When examining the images and dialogue, a deeper understanding of historical events and, more specifically, public opinion, unfolds.

Perhaps due to the flashy façade of comic books, little attention has been directed to the actual context of these sources. The lack of analysis of the images used in media and entertainment formats is based on the fact that “the United States’ image [in Mexico] is largely a United States product.”³ Since the United States is the creator of its own image in other countries, there would be little self-critical analysis. John H. Coatsworth noticed that what is seriously lacking, “of course, are studies of the impressions and opinions created among Mexicans by these United States’ sources.”⁴ By turning a critical eye to printed material of comic books and political cartoons that were created by United States’ companies and cartoonists, but involve Mexico, this research could help fill a void in this field of knowledge.

While comic books may not constitute a viable substitute for history textbooks, comic books do provide a way to supplement the information in the texts and present it in a fashion that may be engaging to readers. There are several com-

ic books that may be used with varying degrees of helpfulness to history students. Some, like *The Cartoon History of the Modern World* and *Exploring the Americas*, are relatively accurate in their historical content and would be best used to introduce younger readers to the sensitive information given about Mexican history. The truth about the numerous deaths of indigenous peoples is discussed in a relatively serious manner and is not sugar-coated. Others, like *Days Missing* and *X-Men Forever: The Secret History of the Sentinels*, utilize familiar historical images and stories, merely rebranding them to create the comic books.

When it comes to engaging young readers about history, *The Cartoon History of the Modern World* fits the bill. This book is a world history textbook, but instead of pages and pages of text, it is arranged in comic book form. In the book's first 48 pages, it examines the history of the indigenous people of Central America and the emergence of the Spanish in the western hemisphere. Some aspects of the book are quite accurate, as it describes how certain groups offered blood sacrifices to their god; others are off the mark, such as the passage in the book that describes the Spanish as reincarnations of gods.⁵ Taking into account the juvenile-inspired depiction of the historical events, it becomes relatively clear that the author is striving toward a more well-rounded portrayal of history than what some readers may have otherwise received.

Towards the end of the Mexican history section of this book, *The Cartoon History of the Modern World* debates some theoretical explanations given by past historians. One panel shows Jared Diamond, a historian/biologist, sharing a bed with a sneezing pig to visualize how his theory of Spanish "conquest" succeeded in the New World.⁶ Another panel shows three scholars talking about how they liked the idea that disease was the main cause of the demise of the indigenous people and "our ancestors hardly shot or stabbed or starved more than a few million."⁷ While *The Cartoon History of the Modern World* may not always portray either the indigenous people or the Spanish in a positive light, these panels show how historians tend to sugar-coat the past so that ancestors' dignities are preserved along with the conquerors' right to the land. By having the historians speak to each other about the actual events in the past, *The Cartoon History of the Modern World* shows readers to look at all the facts and develop an honest opinion about the events that transpired.

Although it does not relate back to any one historical event, the section dealing with the Spanish conquistadors in the New World and the indigenous people who lived there ends with a question for readers: "Can History Judge?"⁸ The author writes that history is "supposed to report stories, to seek causes and effects, to assess, weigh, analyze" the events that transpired.⁹ However, the author acknowledges that there are several compelling questions to ask oneself when reading history. For example, the idea that "we [contemporary readers] can judge their [the past's societies] time too...and try to make our own time more reasonable and humane, and less bigoted by comparison."¹⁰ *The Cartoon History of the Modern World* is just one side to the story of Mexican history. But, by reading several other sources, be it other textbooks, primary documents, films or novels, perhaps exposure to various opinions on these events will help others understand Mexican history.

Exploring the Americas is an amusing take on history as the author seems to imply a foolish Christopher Columbus and sympathize with the indigenous

perspective. At one point, Christopher Columbus says, “My name is Columbus. Do you know the way to Ohio? Never mind. How about gold? Silk? Spices? Chopsticks?”¹¹ These sentences convey the sentiment that Columbus did not know how to travel to China by traveling west from Spain and is focused on the material goods that he would find at those ports. The idea that Columbus is naïve to believe that he found China is expressed when he greets the “Indians” by saying, “Indians! These are the Indies off the coast of CHINA, right?”¹² Readers are shown how ludicrous Columbus’ statements are by stressing the word “China” to show how far off course Columbus was from his desired destination. Of course, this comic book is written with younger children in mind. Since some students might be taught the myth that Columbus was a brilliant man who recognized that the Earth was round before the rest of the world did, the exaggerated dialogue stresses the foolishness of Columbus to correct viewer’s erroneous perceptions of Columbus in a humorous way.

One of the best images and dialogue found in *Exploring the Americas* comes from a chained Indian who tells an enraged conquistador, “Huh! Spanish guys have killed 100,000 of us ‘Indians’ in three years.”¹³ This statement was both shocking and hopeful in this comic book. Unlike the other comics used for this project, this one was designed specifically for a younger audience, most likely elementary aged children. As such, this statement that “100,000 Indians [have killed] in three years” is surprising because most students are taught only the sugar-coated version of the ‘conquest’ of Mexico. Therefore, this blunt statement would provoke the students to have a discussion on what is the ‘correct’ version of history.

While *Exploring the Americas* has a sympathetic tone towards the indigenous people, *Days Missing* does the reverse, and focuses on the power of the Spanish. *Days Missing* tells the story of a time-traveler who wants to save the indigenous people of Mexico from devastation from the Spanish conquistadors. The time-traveling protagonist sabotages the Spanish ships in his quest to save the indigenous people and ends up talking to Hernado Cortez. Despite the time-traveler’s attempts to save the indigenous people, the events in the comic book end up occurring just like they do in history textbooks.

The imagery in *Days Missing* is striking when compared to *The Cartoon History of the Modern World*. Released three years after *The Cartoon History of the Modern World*, *Days Missing* rejects showing the indigenous population in the humanized way of its predecessors. Instead, *Days Missing* seems to draw inspiration from *2012*, released around the same time as the comic book, or *Apocalypto*, released in 2006. Both of these films and the comic book portray the indigenous peoples as savage, barbarians who were inherently inferior to the Spanish. In *Days Missing*, the Aztecs are shown prowling in the jungle, covered in tattoos, wearing only loincloths and appearing to be complete savages.¹⁴ This portrayal of the Aztecs is not accurate because Aztec warriors would have dressed according to their military unit and prowess; such as representing an eagle or jaguar.

Along with negative images towards the Aztec society, *Days Missing* also perpetuates the myth that the Aztecs believed that Hernado Cortez was a reincarnation of Quetzalcoatl, one of the Aztec’s numerous gods. Towards the end of the comic book, the Aztec ruler, presumably Montezuma, asks a messenger, “Are they the creature the Gods have announced? Do they have hair on their faces, do they shine in the sun, and do they ride tall, ugly monsters?”¹⁵ The messenger replies

with, “They do, Your Highness. They are the prophecy.”¹⁶ The ruler responds with, “Then the end of our world is near.”¹⁷ Although the proposition that the Aztecs believed the Spanish were divine beings has since been proved to be a Spanish theme developed to support their conquering of the indigenous people as what the Aztecs called the Spanish “*teules*” does translate to “gods” but is “more ambiguous than that.”¹⁸ *Days Missing* seems to ignore this and eschews historical evidence to fit into the context of the comic book. By doing so, the Aztecs are shown to be superstitious, never sending spies to keep an eye on Cortez so that Montezuma would be aware of the Spanish’s actions.

While *Days Missing* contains historical information, it represents an attractive façade to the ugly truth. The Spanish were not perceived as divine messengers, nor were the Aztecs as barbaric as they were made out to be. Due to the darkness of this piece, this source would serve as a way for older students to examine how comic books, as well as conventional literature, affect public opinion on various topics. Since the Aztecs are portrayed as superstitious barbarians, the Spanish are therefore elevated and the Spanish quest for domination in Latin America is validated.

Out of all the comic books used to examine their historical relevance, *X-Men Forever: The Secret History of the Sentinels*, is the one that uses historical images in the loosest sense possible. While this comic book does not directly discuss the armor-clad conquistadors, it does show the Sentinels—a group of mutant exterminating robots—laying waste to an indigenous-looking village in an undisclosed South American area. Even though Sentinels are fictionalized, they bear a strong resemblance to the Spanish conquistadors and the “conquest” of Mexico. In one panel, the Sentinels are shown surrounding a native village in the middle of a South American jungle, and the Sentinels literally tower over the village and general area.¹⁹ In another, the Sentinels are shown incinerating South American natives.²⁰ The Spanish conquistadors never shot energy bolts from their eyes or hands, but the damage done by the Sentinels and conquistadors is comparable. The Sentinels mercilessly eliminate all who are identified as mutants, just like the Spanish destroyed the majority of the indigenous population through disease and violence.

All of the comic books thus far lend their stories to understanding history better. *The Cartoon History of the Modern World* and *Exploring the Americas* show a more well-rounded view of history for younger students that can stimulate their minds to engage in conversation about how what they knew and what they just learned interact. *Days Missing* and *X-Men Forever: The Secret History of the Sentinels* take images of conquest and recreate them so that their readers will be exposed to familiar ideas and make connections of how these stories tie into the historic past. While all of these sources can help readers get an overall feel for past events in Mexican history, they work best when examined with other sources, such as textbooks.

Aside from retelling Mexican historical events to supplement textbooks, comic books can also take elements from cultural stories to educate a new generation. Marvel Comics, the publisher of *Thor*, and DC Comics, the publisher of *Aztek* and *Wonder Woman*, each published multiple issues that contained elements of the Aztec religion within them. DC Comic’s *Superman Annual #12* and Marvel Comic’s *Last Defenders* also looked at the battle between good and evil as seen through the

Aztec religion. *Thor*, *Aztec* and *Wonder Woman* contain rather accurate depictions of the Aztec gods Quetzalcoatl and Tezcatlipoca, respectively. *Superman Annual #12* and *Last Defenders* take great creative liberty as they recreate Quetzalcoatl for their story. While these comic books are not as historically accurate as the comic books already discussed, they still present information that can be used to examine history and the contemporary viewpoint presented in them.

Quetzalcoatl was an important god for the Aztecs. He was one of the creator gods and, by European mythology standards, a combination of Apollo, the Greek God of light, music and medicine, and Prometheus, one of the Titans who stole fire from the Greek gods to give to mankind. But even this description is lacking and only relates Quetzalcoatl back to a conqueror's viewpoint. Quetzalcoatl was also "Lord of the Morning Star;" one of his symbols was the planet Venus and he "represented healing, magical herbs, beauty and poetry." He was also "Lord of the Winds" and "Lord of Life."²¹ Along with these, Quetzalcoatl's name is a combination from the Nahuatl word *quetzalli* (precious green feather) and *coatl* (serpent).²² This is why Quetzalcoatl is also known as the Feathered Serpent god and is represented with green, yellow, white and red colors. The quetzal bird, which refers back to *quetzalli*, has green, yellow and red feathers and the white is representative of "the quadripartite Tezcatlipoca" and is merely a part of a larger concept of god.²³ The complexity of the Aztec gods stemmed from the multifaceted view the Aztecs held in regards to the nature of life.

This combination of opposing imagery formed from the *quetzalli* and *coatl* also represents Quetzalcoatl's duality. The bird symbolizes heaven at the same time the serpent represents earth.²⁴ This collaboration was intentional, showing how Quetzalcoatl can be destructive, like the serpent, as well as fertile and orderly as the heavens, or the bird.²⁵ Therefore, Quetzalcoatl's portrayal of the Feathered Serpent god represents the chaotic but orderly way of the universe, while also showing the inherent good and evil between himself and Tezcatlipoca. Nonetheless, along with the duality that describes Quetzalcoatl comes the belief that Quetzalcoatl was "to be reborn during each period of history, but with a different face."²⁶ This dualistic quality is key to this research: every time Quetzalcoatl is referenced in a comic book, he never looks the same as he did previously, while his appearances in comic books show how he is reborn into the population's mindset with each creation.

The October 1982 issue of Marvel Comic's *Thor* arguably contains one the earliest American comic book representation of Quetzalcoatl. In this issue, Thor, the Norse god of lightening, calls upon other gods of sun, lightening and thunder, who serve as protectors of mankind, to help him stop a god-eating monster that the underworld gods have unwittingly released. Along with the more well-known Greek Apollo and Egyptian Horus, Thor also calls upon lesser known gods such as the Pueblo Indians' Tawa, Africa's Shango, Hindus' Indra and the Aztec's Quetzalcoatl. Each of the defending gods are introduced and Quetzalcoatl has a caption box that reads "Quetzalcoatl. 'Feathered Serpent' of the Aztecs, his solar disk thrust forth defiantly."²⁷ The creators of this comic book incorporated arrows to look like sunbeams stemming forth from Quetzalcoatl's headdress and his costume is made up entirely of yellow and green—two colors that were definitive of Quetzalcoatl.²⁸ Quetzalcoatl is shown to be a defender as he saves Tawa from the god-eater's grasp. However, it is ultimately Thor who saves the day and rescues

all of his fallen hero gods, including Quetzalcoatl. Even though Quetzalcoatl does not save the day by himself, this is mostly due to the fact that this is Thor's comic book series, making Thor the one who is destined to be the savior.

DC Comic's *Aztek* is one of the most engaging pieces that works with the imagery and theological tradition of Quetzalcoatl. The cover for the first issue, released in August 1996, ran with the tagline "A Hero for the New Millennium... if he lives that long!"²⁹ *Aztek* follows the story of a member of Q Foundation, a group who works to prevent the second-coming of Tezcatlipoca, the sworn enemy of Quetzalcoatl, as he tries to find his place in Vanity, a fictional city located somewhere in the United States. This new Quetzalcoatl wears a suit that allows its wearer to "fly," "have super-strength," and access four-dimensional energy.³⁰ This suit has white body armor, green gloves and outer-underpants, and yellow-gold accessories—including a five-star pointed helmet.³¹ Much like the Aztec interpretation of Quetzalcoatl, the *Aztek* interpretation utilizes three of the four important colors as well as including a helmet that represents a rising star.

While Marvel Comics heavily draws its influence of *Aztek* from Aztec mythology, Marvel Comics makes the hero a blonde, chiseled white male. By having a white male hero, instead of one of indigenous descent, Marvel Comics lost the opportunity to recreate Aztec history, instead choosing to rewrite history and make it their own. Perhaps one of the best examples of how the population misunderstands Mesoamerican history takes place between three journalists who are trying to determine a codename for Vanity's newest superhero. One of the journalists says "He looks like an Inca, not an Aztec. How many times do I have to repeat myself here?"³² However, this journalist is overruled by his colleague who, based on the technology used in his suit, thinks that "Aztec" with a "k" would be the best codename for the new superhero. Thus, *Aztek* was born. The dialogue in this scene seems to imply that the general population has no idea how to differentiate between the ancient civilizations that existed in Central to South America.

Looking at *Aztek's* personality found in the *Aztek* comic books, the creators shied away from Quetzalcoatl's creator side and instead focused on him as a cultural hero. Following the continued belief in Quetzalcoatl's divided nature, his personality is split depending on the literary traditions. Typically, Quetzalcoatl's creator side, the one "in which he participated in the creation and destruction of the cosmos and moved the wind," is usually referenced in "ancient oral traditions."³³ In this case, Marvel Comics utilized Quetzalcoatl's "culture hero side," which is associated with Quetzalcoatl's legitimizing "emerging states and provided a morally upright governance model" and first appeared in "oral tradition," but has quickly been adopted by literary models that picks up and expands on the themes found in the oral tradition.³⁴ Therefore, most of the comic books examined that deal with Quetzalcoatl usually use the culture hero aspect of the god.

While *Aztek* shows the cultural hero side of Quetzalcoatl, Marvel Comic's *Last Defenders* issues one and two examines the Feathered Serpent aspect of Quetzalcoatl. The first issue begins with a rag-tag group of superheroes called the Defenders, who need to stop "The Sons of the Serpent," an "extremely xenophobic hate group" that is "basically the Klan in snake outfits."³⁵ While the Sons of Serpent's goal is not clear, some of the members talk about how they are willing to take their new "organic weaponry" to Mexico, allowing it to be "the first step in fixing the immigration nightmare."³⁶ Unfortunately for both the Defenders

and the Sons of the Serpent, the Sons of Serpent's ritual to bring about their new organic weapon misfires and Quetzalcoatl is unleashed to destroy New Jersey. Unlike the Aztec's Feathered Serpent Quetzalcoatl, who was a defender for the Aztec people, the *Last Defenders'* interpretation of the Feathered Serpent god is more akin to a winged Godzilla monster. While this imagery seems extremely ill-informed, it is not the first time this image of Quetzalcoatl as a monster has been displayed. In 1982, a film called *Q* was created where "ersatz Aztec religions and rituals become fused with science fiction" to show Quetzalcoatl, in his Feathered Serpent form, attacking New York City from the Chrysler Building.³⁷ Both *Q* and the *Last Defenders* are vehicles to distract viewers from reality, but these forms of entertainment seem to have a deeper meaning: those of Hispanic descent are seen as a threat. In *Q*, Quetzalcoatl—a symbol to the Aztec, and by association, the Mexican people—is shown destroying one of the United State's most populated cities. In *Last Defenders*, Quetzalcoatl rampages about New Jersey despite his original design to destroy the culture it originally came from.

Much like the journalists in *Aztek*, characters in *Last Defenders* struggle with how to identify Quetzalcoatl. One of the heroes, Blazing Skull, represents the majority of the population as he struggles with saying the name "Quetzalcoatl." As the team recounts how they failed to stop the rising of Quetzalcoatl, the Blazing Skull calls the creature "Ol' Quackenbush."³⁸ The ignorant Blazing Skull counterpart is the intelligent She-Hulk. She-Hulk is the one who first identifies Quetzalcoatl after it was raised by the Sons of the Serpent, explaining to her teammates that Quetzalcoatl is a "mythical Aztec snake creature" and corrects Blazing Skull's mispronunciation.^{39, 40, 41} By having both the Blazing Skull and the She-Hulk in this issue, Marvel Comics allows readers, who may be ignorant like the Blazing Skull, to understand what the team is fighting when She-Hulk correct her teammate's mistakes.

The Feathered Serpent in *Last Defenders* is colored similarly to an Aztec version found in the Codex Telleriano-Remensis.⁴² Both forms of this Feathered Serpent contain red, yellow and green plumage. However, the Aztec's version is more snake-like in appearance while the *Last Defenders'* looks like a winged Tyrannosaurus Rex. The Aztec's Quetzalcoatl is shown swallowing a victim while Marvel Comic's design merely destroys buildings. Essentially, the Aztec's Feathered Serpent is always a god; some divine protector who defends the just and destroys the guilty. The *Last Defenders'* Feathered Serpent is a mindless weapon; something that exists only to destroy everything in its path. This complete change in ideological meaning demonstrates that even through the recreated image is similar to the original, current mindset can influence the meaning to mean something completely different than the original.

As briefly mentioned earlier, Tezcatlipoca is the Aztec god of darkness, an evil god. However, there is more to Tezcatlipoca than just that simplification. Tezcatlipoca is known as the lord of the smoking mirror, death, war, trickery and was represented as a jaguar.⁴³ Out of all of Tezcatlipoca's elements, it was the mirror that "was the most significant determinant element" and was placed somewhere on his person.⁴⁴ This smoking mirror, sometimes also known as an obsidian mirror, relates back to the Aztec belief that everyone walked on the edge of an obsidian blade and even obsidian mirrors are placed on the chests of gods so that the people praying would be praying not only to the god, but also to themselves. Unlike

Quetzalcoatl's bright colored animal counterpart, Tezcatlipoca could turn himself into a jaguar due to his "close relationship with those felines of the night."⁴⁵ Essentially, everything that is used to describe Quetzalcoatl could, in theory, be used to describe Tezcatlipoca; they are the flip side of the same coin.

Much like Quetzalcoatl, Tezcatlipoca can be identified in artwork due to some key characteristics. Tezcatlipoca has four colors that are representative of him; blue, yellow, red and black.⁴⁶ It should be noted that Quetzalcoatl and Tezcatlipoca share yellow and red in their color schemes, which could be attributed to their dual nature. Between the remaining two colors, blue and black, black is "undeniably the main characteristic in all descriptions" of Tezcatlipoca.⁴⁷ Further, Tezcatlipoca usually has "stripes [that] are painted across his face."⁴⁸ Another bodily detail that relates back to Tezcatlipoca is that he is sometimes shown with a leg made of obsidian, which represents the walking on an obsidian blade and also a sacrifice that Tezcatlipoca gave in creating the world.

Although Tezcatlipoca is a key part of the *Aztek* comics, he is only seen once in the first ten comics. Tezcatlipoca is shown as a were-jaguar lying on the ground with blood covering the area around him as Quetzalcoatl (or at least a member of the Q Foundation using the Quetzalcoatl suit) had bloody hands.⁴⁹ Along with this image of good triumphing over evil, the caption box on that page states "their [Quetzalcoatl and Tezcatlipoca's] next meeting will be called the apocalypse."⁵⁰ Even though Tezcatlipoca is shown in his animal representation, Quetzalcoatl is clearly in the shape of a man wearing a helmet, breastplate, and pants. This imagery seems to show that Quetzalcoatl is the more human, civilized, and righteous god, while Tezcatlipoca is a violent, animalistic creature who deserves to die.

While the imagery presented in *Aztek* is acceptable as a basic explanation, illustrating the Aztec gods' battle, it does not take into account the complexity of the gods. Despite his goodness, Quetzalcoatl was also a slave to human desire. At a feast for the gods, Quetzalcoatl drank too much and had sexual relations with one of the goddesses—which in some cases is said to be a female relative and in other a demonic goddess.⁵¹ Filled with shame, Quetzalcoatl banishes himself as a form of penance. Granted, Tezcatlipoca is said to have laced Quetzalcoatl's drink, but Quetzalcoatl was the one who drank it, or too much of it. Some may accuse Tezcatlipoca of being a cruel trickster, but sometimes his tricks are used to teach a person a lesson. In this case, Tezcatlipoca might have been trying to teach Quetzalcoatl not to drink too much. Even though the gods are assigned opposing descriptions for worship—light or darkness—these gods are not complete opposites. These gods did work together to create the universe and they contain elements of duality within themselves. An otherwise benevolent god like Quetzalcoatl can make unwise choices after consuming too much alcohol and why an otherwise evil god like Tezcatlipoca can create the universe; there are elements of good and evil in both gods, but usually one side dominates the other.

In DC Comic's *Wonder Woman* issues 313 to 316, there is no doubt that Tezcatlipoca is evil. Initially traveling to save a fallen comrade, Wonder Woman discovers that Circe—a Greek sorceress who turns men into her animal slaves—is the one responsible. Circe tries to best Wonder Woman, but she is overwhelmed and invokes her lover and the true mastermind: Tezcatlipoca. Though, Tezcatlipoca is shown numerous times in issues 313 and 314 as an obsidian mirror-wearing jag-

uar, it is not until the end of issue 314 that Tezcatlipoca shows himself in his god form.⁵² While he lacked an obsidian leg, this version of Tezcatlipoca is shown with the traditional painted stripes on his face and is clothed in red, yellow and blue.⁵³ The only thing lacking in this depiction is that the only black element found on Tezcatlipoca's is the obsidian mirror hanging on his chest. For a god who is known by the color black, this omission is an oversight by the comic's creators.

Along with the jaguar, obsidian mirrors are indispensable to Tezcatlipoca. Besides the obsidian mirror chest plate, obsidian mirrors are seen throughout Tezcatlipoca's Aztec village. Upon her arrival to Tezcatlipoca's domain, Wonder Woman finds a "building [that] looks like a temple—adorned with mirrors that tilt towards the sun."⁵⁴ Remembering that "the sun was of central importance to the Aztecs...and the dark mirror seems to be Tezcatlipoca's trademark," Wonder Woman deduces that this is where she would find him.⁵⁵ Upon entering the temple, Wonder Woman comments that since there are several mirrors that are on the walls and ceilings, she'll be extremely "lucky to stay in a straight line."⁵⁶ The Aztecs understood Wonder Woman's sentiments as they thought of it hundreds of years before her; life demanded that everyone walk on the thin edge of an obsidian blade, one slip and the entire balance would be thrown off.

The cover for *Wonder Woman* issue 315 shows Wonder Woman staring at several distorted versions of herself as they appear in the obsidian mirror.⁵⁷ Later, in the same issue, Wonder Woman is shown her deepest desires and fears from an obsidian mirror covered audience chamber.⁵⁸ Wonder Woman sees her reflection in a power-hungry version, as a man and even as a scared little girl.⁵⁹ Even though Wonder Woman has "locked those thoughts away—so I can never harm those whom I must protect," the obsidian mirror reveals those repressed aspects that make Wonder Woman the heroine she is.⁶⁰ This idea that the obsidian mirror reveals all comes from the pre-Hispanic tradition that the obsidian mirror shows not only the viewer's reflection, but also whatever is behind the mirror. In this fashion, Wonder Woman sees not only her outward appearance in the mirror but also her numerous internal aspects.

Unlike other interpretations of Tezcatlipoca, such as in the *Aztek* comics, the *Wonder Woman's* portrayal of Tezcatlipoca was more as a conveying trickster instead of a soulless killer. Once Tezcatlipoca revealed his true form to Wonder Woman, he says that his "Aztec worshipers called" him "the Mad God, the Mocker, the Jaguar Lord, the Master of the Smoky Mirror!"⁶¹ The ultimate goal for Tezcatlipoca was not to dominate the world, but to be separated from his mortal host.⁶² By destroying Tezcatlipoca's human host, Wonder Woman unwittingly allowed Tezcatlipoca to return to his god-like form and thus gave him the ability to control the minds of humanity.

All in all, *Wonder Woman's* interpretation of Tezcatlipoca is in line with Aztec mythology. However, as he was missing his obsidian leg, lacked the color black and seemed to be more into trickery than evil deeds, Tezcatlipoca was very similar to Marvel Comic's Loki, the Norse god of trickery that makes frequent appearances in the *Thor* comic books. In the case of this comic book, DC Comics seems to have been using the same idea of a trickster villain god who creates more confusion than malice instead of creating something totally unique. However, there is no denying that DC Comic's portrayal found in *Wonder Woman* 313 to 316 presents a decent representation of this Aztec god.

DC Comic's *Superman Annual #12* represents the continued battle of good

and evil between Quetzalcoatl and Tezcatlipoca. Very similar to the plot for the *Last Defenders*, *Superman Annual #12* revolves around the idea that a group of terrorists want to use pre-Hispanic ideas and beliefs to wreak havoc on their city of choice. The unnamed eco-terrorist group in *Superman Annual #12* is led by a man called Duran who uses an amulet with the symbol for “Ometeotl...God of the Near and Close” to channel the earth’s power through an innocent little girl.⁶³ The climax of the story comes when Acrata, the Mexican super heroine, translates the amulet to discover how Ometeotl prophesized that a girl would “harness the negative power of the Earth” and that only a “visitor from the stars” would be able to harness the positive energy.⁶⁴ Despite the fact that the Mexican superheroes are battling a group in Mexico City and that the eco-terrorists are using Aztec prophecies and artifacts for their deeds, it is the American Superman who saves the day.

The whole concept of harnessing power for either ‘good’ or ‘evil’ purposes continues the concept of duality which the Aztecs embraced. However, unlike the usual Tezcatlipoca or Quetzalcoatl to represent the different stances of opposing sides, the writers chose to use Ometeotl—the combination of both Tezcatlipoca and Quetzalcoatl—to represent the duality.⁶⁵ By using Ometeotl, the writers for this comic book chose to provide readers a new aspect of the Aztec pantheon. However, given how Ometeotl represents the maximum duality of the Aztec gods and is thought to be the Father of the Gods, it would seem to imply that Superman has more power than the rest of the superheroes. Thus, according to the plot of this comic book, Superman has taken a leading role in the power structure of the superhero world, while also assuming the cosmological power of Ometeotl.

Perhaps one of the most ironic items in this comic book was the reference to the Mexican World Trade Center. The comic book, released in 2000, states that “Unlike the United States’ World Trade Center, Mexico’s W.T.C. has never suffered a devastating terrorist assault...until now.”⁶⁶ Reading this comic book almost ten years after September 11, 2001, this statement seems to foreshadow just how vulnerable the United States’ World Trade Center was in comparison to Mexico’s. This statement also serves as a reference point as the United States’ World Trade Center building had suffered bombings and other attacks that its Mexican counterpart can only suffer in comic book format. This description also shows how egotistical the American writers were to reference their own World Trade Center building, or that they perhaps thought about providing the American audience with a reference point to situate themselves in Mexico City.

Along with comic books, Mexican history can be traced through political cartoons. While political cartoons are several panels shorter than comic books, political cartoons can still convey powerful imagery about historical events at a given point in time. By examining political cartoons on a certain topic—illegal immigration and drug trafficking, for example—one can understand how public opinions in the United States have shifted, or remained static, over a course of a time. Unlike comic books, political cartoons are created for a more mature demographic as they can be found in several newspapers worldwide.

An extremely polarizing topic in the United States government is the illegal immigration of Mexican citizens to the United States. This topic not only refers to the actual event of immigration from one country to the other, but is also an umbrella term to refer to all of the underlying results which flow from this one event. There are opposing claims concerning how illegal immigrants affect

jobs, government policies and citizenship in the United States, and these conflicts have led to discussion on how to best go about modifying process. Some proposed responses to the illegal immigration issue between the United States and Mexico have ranged dramatically from creating a wall along the United States-Mexican border to the Dream Act.⁶⁷ As of this writing, there seems to be no clear direction on how to reconcile this hot-topic issue in the United States. Nonetheless, by following news articles and political cartoons, one can see how public opinion has shifted.

Perhaps one of the largest issues with illegal immigration is how undocumented Mexican immigrants affect the United States' job market. Some of the political cartoons that were used for this research showed a sympathetic view to the Mexican immigrants' plight while others accusingly portrayed these same workers as selfish, lazy and irrational beings. This negative feeling towards Mexican immigrants is especially prevalent in border states where the general perception is the immigrants "steal jobs from U.S. citizens of long standing and who overburden the welfare and education systems."⁶⁸ Along with this, there are also many stereotyped images of Mexican Americans including the "disadvantaged immigrants, advantaged immigrants, binational consumers, commuters who cross the border on a regular basis to work, biculturalists, binationalists, and U.S.-born Mexican Americans who live and work on the Mexican side of the border."⁶⁹ Clearly, this wide array of feelings and thoughts concerning illegal immigrant workers in the United States shows that there must be a variety of political cartoons that deal with these ideas. However, it was surprising that one political cartoon presented both sides of these opposing views so as to offer a moderate, uniform presentation of the topic.

There were three political cartoons used in this research to show a sympathetic view to the illegal immigrant workers in the United States. One of the political cartoons shows an illegal immigrant working at a "Taco Bull" cashier window telling a customer "We illegals only take the jobs American won't do."⁷⁰ This political cartoon reflects the position that working at a fast food restaurant—like this fictional "Taco Bull"—is beneath the American public, and thus an acceptable form of employment for illegal immigrants. Along with disparaging the American public's elitist attitude toward certain forms of employment, it denigrates the illegal immigrants willing to take these so-called "undesirable" jobs.

A more recent political cartoon tells the story of an illegal immigrant who was "born in Mexico" and "crossed the border into the United States" where he "took the menial jobs that no one wanted."⁷¹ This political cartoon depicts how the speaker in the political cartoon came into the United States illegally, worked hard to learn English, provide for his family and become an American citizen. Despite this character's accomplishments, it ends on the bitter-sweet note that he lost his job after his employer moved to Mexico. This political cartoon demonstrates that even though illegal immigrants work to become citizens of the United States, the same drive for cheap manufactured goods which first drove illegal immigrants to come to the United States to provide cheap labor has now been undermined by American companies working towards the bottom line by moving to Mexico. By creating this political cartoon, the cartoonist was depicting how American consumerism not only affects illegal immigrants' lives, but the overall condition of American society.

The final political cartoon that shows a sympathetic view on illegal im-

migrant workers is one that was created after Arizona's state government decided to implement a new policy of asking anyone of Hispanic descent to present proper government paperwork to prove their citizenship. The cartoon shows a Hispanic worker being asked by an Arizona police officer to present the Hispanic worker's "immigration papers" due to suspicious activities.⁷² While this political cartoon does not necessarily say that this Hispanic worker is an illegal immigrant, it suggests that he might be because he asks the police officer if the officer would like to see immigration papers "before or after I finish your lawn."⁷³ In this fashion, the political cartoonist is showing how American society holds a double standard as a whole; the society wants cheap labor but despises illegal immigrants. In this way, the cartoon reveals American society to be a greedy nation and illegal immigrants as being exploited.

Along with these political cartoons showing sympathetic views toward the plight of illegal immigrant workers in a greedy, American society, these political cartoons were released from 2009 onward. While the timeframe for these political cartoons are not solely responsible for their message, they can demonstrate that American society is learning that the United States is not a perfect society. These political cartoons correspond best with the *X-Men Forever* comic book. Together these sources portray an overall image where the "conquering" population—in *X-Men Forever* the Sentinel robots, and in the political cartoons the American population—is not as benevolent as the general population would be led to believe. These sources allow the readers to see that sometimes the thing that is perceived as good—eliminating the mutant population as the Sentinels were programmed to do, or shunning illegal immigrant workers in the United States—is the exact opposite.

The five political cartoons reviewed here cast an unfavorable light on the illegal immigrant workers in the United States. Most show the illegal immigrant workers to be greedy job-snatchers and some even play on the stereotype that these people cannot speak English. One of the most backhanded political cartoons from this group was one that showed Uncle Sam and Lady Liberty in a restaurant as Uncle Sam complains, "Don't you hate it when the help speaks a foreign language?!"⁷⁴ The help in question, a waitress carrying dishes and a waiter, were not speaking broken English but holding a sign "Will we ever get sensible, bipartisan immigration reform?"⁷⁵ While Uncle Sam's response may seem reasonable compared to the help's unreasonable call for reform, the exact opposite can also be seen. There is no easy way to decide who is right or wrong in this situation as two different readers could see the different views, this political cartoon still shows that there is an unclear policy issue in the United States concerning illegal immigrant workers.

One of the most shocking political cartoons to show anti-illegal immigrant worker feelings in the United States was one that was published in September 2010. In this example, two United States border patrol officers are sitting under a sign that reads "No Jobs" and saying that even though they had previously tried everything ("dogs, helicopters, night vision, towering border fences"), it was this easy sign that did the trick.⁷⁶ This simplistic approach to illegal immigrants from Mexico seems to imply that those who come to the United States are only interested in stealing jobs from Americans. However, there is more to this situation than just jobs. Most of the illegal immigrants want to come to the United States to achieve a higher quality of living for themselves and their family. Granted, this is

usually accomplished by first having a job, but jobs are not the sole driving force behind illegal immigrants coming to the United States.

A 2007 political cartoon by Terry C. Wise shows a scheming illegal immigrant worker in the United States. Two Caucasian supervisors are watching some workers and one of the supervisors says, "Sure he's an illegal...but he's doing work nobody else wants for the pay. It's not like he's after OUR jobs!" The illegal worker in question, overhearing his supervisors, thinks "Not today, gringo...not today."⁷⁸ Examining only the dialogue in this political cartoon, it shows that while the illegal immigrants are currently only working the most undesirable jobs in the United States; it is only a matter of time before they work on taking over the entire work system and threaten the middle and upper classes. One important element in this political cartoon is the word "gringo." "Gringo" is a Latin American slang term to refer to "a foreigner, esp. one of U.S. or British descent."⁷⁹ By choosing to use this term, the cartoonist was signaling to the readers, especially in the United States, that they should be wary of the cheap, illegal immigrant workers. It is this cartoonist's view that the United States' labor system will soon be swallowed up from the bottom up as these illegal immigrant workers start to move up the ladder in their employment situation.

Along the same line of job-stealing illegal immigrant workers, there was a more emotionally compelling political cartoon about this topic as well. In this political cartoon, a distraught worker stands in front of a U.S. Factory where a sign says "This year's [Labor Day] picnic will be held in Mexico, where your job went."⁸⁰ Although there is no mention of illegal immigrant workers, this political cartoon shows how Mexico affects the job market in the United States. However, it is important to remember that it was not Mexico who stole away these United States factory jobs, but rather it was the factory's choice to move. The now jobless United States factory worker is a victim of United States consumerism as the U. S. Factory chose to move their business to Mexico to better their bottom line.

The final political cartoon represents how illegal immigrants steal profits from the United States. This political cartoon shows an illegal immigrant pocketing some apples and placing them in this "Profits" bag as a large hand—U.S. immigration—comes to pick the illegal immigrant.⁸¹ In this portrayal, the illegal immigrant is being shown to pick profits, and thus hurting the bottom line of the country's economy. To remedy this situation, the U.S. immigration is shown to pick this "bad apple" of illegal immigrants from the picture. Thus, this political cartoon shows that illegal immigrants are detrimental to the economy and should be taken out of the equation.

The most unbiased political cartoon shows how "Big Biz" and "ICE" deal with illegal immigrants in the United States. Two representatives from these two groups are posting "Wanted" signs for the same person, but for different reasons. Big Biz, or big business, is looking for "cheap, disposable labor" "to keep our profits going thru the roof."⁸² The ICE, or Immigration and Customs Enforcement, representative is looking "for immediate deportation" "to keep the help in their proper place."⁸³ These two representatives are looking for the same, illegal immigrant worker but for opposing reasons prevalent in the United States. By showing these two representatives and similar looking posters side-by-side, the cartoonist is showing both viewpoints so that readers can make their own choice when presented with two sides of the story.

With the exception of the indigenous people of North America, the majority of the United States' population has taken advantage of citizenship either through government policies or through being born in the United States. However, a sore topic for some in the United States is how pregnant, illegal immigrants will do everything possible to come into the United States so their child will be born in the United States and obtain benefits through the Fourteenth Amendment, which provides citizenship for the child. Since the new United States citizen could not take care of itself, the mother would be allowed to stay. Given the increase in illegal immigration from Mexico to the United States, the offspring of these illegal citizens is an issue that has been discussed numerous times in political cartoons.

In the fall of 2010, the United States started to hold a new discussion about the children of illegal Mexican immigrants born in the United States. The children in such situations are referred to as "anchor babies" as they "anchor" their mother—and essentially their family—to the United States, their birth country. While some United States citizens feel that these children unfairly allow people to stay in the United States, one political cartoon points out one glaring, hypocritical fact. In this political cartoon, two Native Americans are seen standing in a forest watching a pilgrim couple holding their new baby. One of the Native Americans says, "#@! Anchor babies!"⁸⁴ Essentially, this political cartoon shows that very few of the United States' population can claim to non-anchor babies. By trying to change the rules of American citizenship through birth, many United States citizens would need to change their own citizen status to illegal.

While the previous political cartoon shows the irony of anchor babies in the United States, another political cartoon took a more aggressive view against those who would complain. This political cartoon shows a Caucasian male in a suit, pointing to a Hispanic family, saying "It's time to reclaim America from illegal immigrants!"⁸⁵ A Native American male stands to the right of the speaker and tells the speaker, "I'll help you pack."⁸⁶ Much like the cliché of the pot calling the kettle black, so is the Caucasian (unintentionally) calling himself an illegal immigrant as the Native American has the greatest claim to the United States' citizenship. Thus, the idea of an illegal immigrant is a rather absurd concept because there are very few United States citizens who were legal citizens when the United States was colonized.

A final political cartoon that focuses on the citizenship issue shows that it is not the parents who are punished, but the innocent child. In this political cartoon, a delivery room doctor is shown slapping a recently born baby's bottom at the same time that a "Dept. Immigration: Anchor Baby Patrol" officer is slapping handcuffs onto the baby's wrists.⁸⁷ This political cartoon seems to claim that law enforcement agencies are going to have to overstep boundaries to get to the next law-breakers, namely those children who were born in the United States. While this might be a minor note, it would appear that the baby in question in this political cartoon seems rather Caucasian. Even though this is a minor acknowledgement, this might have been done to ensure that the political cartoonist was not stereotyping; however this usage would be ironic as this is what the officer would be doing. This political cartoon supports some regulation in regards to the children born to illegal immigrants in the United States, but not to such a satirical depiction as presented here.

Moving away from the sensitive subject of how to manage the citizenship status of anchor babies, there are other disagreements over how to treat illegal

immigrants through United States government policies. In the political cartoons that focus on the perception of government policy towards illegal immigrants, the policies were considered insensitive. Much like other political cartoons, these three researched political cartoons do not assertively discuss their ideas, but imply them. As such, these political cartoons look at some of the absurd ideas that take place in regards to how government policy affects illegal immigrants.

One of the first political cartoons examined is very reminiscent of Dr. Seuss' *Horton Hears a Who*. In this political cartoon, the Republican-dominated Congress—represented by the party's elephant—is holding a dandelion titled "Immigration Reform" and is shown thinking that "I [the Congressional elephant] swear I can almost hear something."⁸⁸ Unlike Dr. Seuss' story, the Whos who lived on the dandelion's dust speck are replaced with a large group of Hispanic people surrounding the elephant saying "We are here! We are here! We are here!"⁸⁹ Unlike Dr. Seuss' Horton, who was the only one to realize that there was a city on the dust speck due to his elephant-sized ears, this Congressional elephant seems to be the only one who does not realize that the Hispanics—or "Whos"—exist. This political cartoon shows that the Republican congress was unaware of how a large part of the United States was in favor of immigration reform.

Perhaps one of the most tongue-in-cheek critiques of government policy included how the Statue of Liberty's inscription was used against her. In this political cartoon, the Statue of Liberty is in a police office where one of the supervisors, seated in a judge's podium, asks the Statue of Liberty "Conspiring to harbor felons, eh?"⁹⁰ Where the Statue of Liberty's inscription once inspired comfort and hope for the "tired," "poor" and "wretched refuse" who longed for a new life, this same inscription seems like a confession for having welcomed illegal immigrants to enter the United States.⁹¹ Where once the United States was willing to increase its citizenship by welcoming all those who felt unsafe in their native country, the United States now seems to be back-pedaling by trying to maintain its current number of citizens at the same relative composition and total. By trying to limit who can enter the United States, the United States is retreating from those ideals which made it a great country.

The final political cartoon contrasts the daily routine between an illegal immigrant worker and a United States citizen. In this example, the illegal worker's life is narrated in each gritty, difficult detail. Instead of the stereotype perception that the illegal immigrant is a lazy, job stealer, the narrative discusses the inhumane lifestyle that he is forced to endure so that his family can have a chance for a better life. On the flip side, the United States citizen is portrayed as having the easy life as he "woke up, found marker pen, made sign."⁹² In this way, it is not the illegal immigrant worker who is shown as the negative representative of the United States, but the United States citizen. This portrayal of these workers being "courageous, hardworking individuals who sacrifice for their families" is typical of Mexico.⁹³ Therefore, this illegal immigrant worker is shown to be trying to achieve the American Dream of providing a better life for his family while the United States citizen is working on squelching any and all possibilities of that dream.

So, if the United States seems incapable of creating an acceptable immigration policy that all can agree on, the solution should reside outside of Congress. It is this thinking that has led some citizens in the United States to take a very physical way to stop illegal Mexican immigrants: building a wall along the United

State-Mexican border. Five political cartoons examine this solution. Some show the futility of having a wall, while others show it to be a waste of resources, and still another shows it to be a menace. Regardless of their feelings on this topic, these political cartoons discuss how the United States should interact with Mexico.

One political cartoon showed the futility of building a wall that would separate Mexico from the United States. In this political cartoon, there is a booth on the Mexican side of the border offering “Maps to USA.”⁹⁴ Even though the United States side has a large “U.S.A. Keep Out” sign, there are smaller booths offering “Free Lemonade,” “Free Education,” “Jobs,” and “Free Health Care.”⁹⁵ The only thing separating these two countries is a chain-link, barb-wired fence that has a hole at the bottom of a fence. The cartoon implies that despite the large “Keep Out” sign to designate the United States, the country does little to discourage the illegal immigrants from coming to the country. By offering jobs, free education and (apparently) free health care to all comers, the United States makes this country an appealing place that rewards its residents—both legal and illegal—with these offers.

Two political cartoons showed the futility of building a wall as it would lead to a lack of resources and thus a waste of time. One political cartoon shows workers constructing a “20-foot tall border fence” to separate the United States and Mexico as one man puts on the finishing touches to his “21-foot ladder rentals” sign.⁹⁶ A wall—regardless of its height—might slow down illegal immigration but not completely stop it. Those who are determined to come to the United States would do everything they can do make it possible, including getting a ladder that is one inch higher than the wall.

The other political cartoon shows how creating the wall would be hypocritical. The main contractor asks Uncle Sam, “Can you get me some huddled masses yearning to bust their humps for five bucks an hour?”⁹⁷ The irony of this question is more dramatic when understanding that the questioner is working on construction of the border wall. Looking at all of this information, it would seem highly unlikely that the contractor would be able to get the workers he needed solely from the United States, because many Americans would see the job as beneath them. However, illegal immigrants might be willing to snap up this undesirable job because it is a job. Thus, the contractor might have to rely on illegal immigrant workers to create a wall to keep others just like them out of the United States.

One of the sharpest critics of the wall was a political cartoon that showed a mound of skulls. The mound of skulls was stacked in such a way that they formed a wall where the United States flag was stacked at the top.⁹⁸ While this mound of skulls could be used to represent a number of topics ranging anywhere from those who died during wars to those who died as the United States expanded, it can also be used to show those illegal immigrants who died while coming to the United States. When looking at the illegal immigrant point of view, any wall built to separate the United States from Mexico would result in more harm than good as the number of deaths that resulted on their journey will create a wall.

Some critics of the United States-Mexican border wall see the creation of this wall as a reincarnated form of the wall that separated East and West Germany. This imagery is represented in a political cartoon where a big nose Uncle Sam peers over a brick wall to Mexico.⁹⁹ While such a wall might cut back on the num-

ber of illegal immigrants from Mexico coming into the United States, its presence would seem to be ominous. Some might see the wall as a protective structure, while others might see it as an oppressive symbol. This political cartoon definitely seems to take the stand that this wall would be an oppressive one.

The public opinion regarding this topic is indeed mixed. Accordingly, by tracking opinions on this subject through political cartoons, one can see how public opinion shifts over time. However, perhaps given the current state of the United States' economy, the idea of creating a wall along the United States-Mexican border may no longer be cost-effective. Therefore, political cartoons may start shifting away from ones concerning a wall to other proposals concerning how to deal with illegal immigrants, such as the Dream Act.

In December 2010, there was a vote in the United States' Senate on a new response to illegal immigration in the United States: the Dream Act. Had the Dream Act been approved, it would have qualified "undocumented youth" to "be eligible for a 6 year long conditional path to citizenship that requires completion of a college degree or two years of military service."¹⁰⁰ While this Dream Act would not affect illegal immigrant parents, the children that were born in the United States by these illegal immigrants—who have no ties to their ancestral home—would have a chance to legitimize their citizenship is a relatively recent proposal.

Because the Dream Act is so new, there have not been many political cartoons created on this subject. However, on December 21, 2010, political cartoonist Tony Auth decided to create one about this issue. In this political cartoon, a family of "exponential Hispanic growth" runs into a Republican elephant who had just thrown away a copy of the Dream Act and announce "We're the Spirits of Christmas yet to come, Señor!"¹⁰¹ This political cartoon argues that the Scrooge-like Republicans might suffer in future elections from a future, powerful voting demographic. Perhaps future researchers will examine political cartoons starting with this one to see how public opinion went from Tony Auth's pro-Dream Act to either those who supported or opposed the Dream Act.

Given the number of political cartoons discussed thus far, it is hard to even dream that there could be more, but there are. The political cartoons discussed in this paper provide a mere glimpse at some of the topics that political cartoonists have discussed based on—at the time of their creation—current events. Keeping in mind that the news is one industry that is constantly growing and updating with new stories, political cartoons are going to continue examining what was printed between the cover and last pages. Examining the current news environment, it is a safe bet that more political cartoons discussing the United States' feelings in regards to illegal immigration and the growing Hispanic vote is going to be used quite often in the upcoming years.

Along with illegal immigration, drugs in Mexican culture have been a source of fodder for United States political cartoons. There seemed to be an increase in drug and Mexican related political cartoons starting in early 2009. Around this time period, there was an increase in drug-related violence that was spilling over the Mexican border and into the United States. By examining nine political cartoons from 2009 to 2010, one can see how both the United States and Mexico are responsible for this drug problem.

The first political cartoon to be discussed in this set appeared in February 2009. In this political cartoon, a very buff and intimidating man wearing a shirt

that reads “Drug Cartels” is playing with a piñata labeled “Mexico.”¹⁰² Unlike the typical image of candy falling out from the piñata, this piñata is shown leaking skulls. As such, instead of providing treats to Mexico, the drug cartels are shown to be ripping the country apart at the seams and causing numerous deaths. This political cartoon represents the atrocities that are associated with the drug cartels and the negative affect they have on Mexico.

Another political cartoon around this time period shows how interlocked the United States and Mexico are in the matter of drug wars. On the left hand side of this political cartoon are “USA Users” doing a lot of “shooting up,” as in shooting up with heroin, while the opposite side shows a man holding smoking guns and labeled as “Mexican Drug Cartels.”¹⁰³ In this way, the political cartoonist is showing that until the United States controls its drug users, the Mexican drug cartels will not be stopped. Therefore, while the Mexican drug cartels are indeed a problem as they shoot and kill people, the United States drug users are a stimulus for this problem because they use the products of the Mexican drug cartels.

This mutual responsibility is shown in another political cartoon where Uncle Sam and a Mexican representative stand on either side of a broken fence. On the United States’ side is “drug demand” and on the Mexican side is the “drug supply.”¹⁰⁴ Even though the United States and Mexico should share the responsibility for repairing this broken fence, both think that “He [the person on the other side] needs to fix his fence...”¹⁰⁵ Much like the previous political cartoon that examines the relationship between the drug demand and supply between the United States and Mexico, this political cartoon shows that there is an apparent connection, even if the government officials do not recognize it. The answer to this problem is not to build a wall, but for the United States to end their drug demand and for Mexico to stop supplying it.

Even though there appears to be equal responsibility for both Mexico and the United States, it seems that the United States is also contributing something to this drug problem: weapons. In this United States-created political cartoon, a dump truck that sports the United States flag on its door is shown dumping its supply of guns and weapons into Mexico.¹⁰⁶ Even though some citizens of the United States feel like they are the ones that need to build a wall to stop the flow of drugs, the sentiment in this political cartoon is that it is Mexico that needs to build a wall to stop the importation of weapons from the United States. Despite the mutual responsibility, this political cartoon implies that the United States needs to do more to stop the problem.

The intensity that this drug problem has created in Mexico is shown in another political cartoon. In this cartoon, two “Mexican police” officers are shown shooting while other bullets whizz past them.¹⁰⁷ Despite the gunfire around them, one of the police officers asks his partner “Where are you going for vacation this year, Pedro?” and his partner answers, “Oh, someplace peaceful...maybe Baghdad, Rwanda, Afghanistan...”¹⁰⁸ Given the extreme violence that occurs in Baghdad and Afghanistan, the idea that someone would want to vacation there is mind-boggling. However, this exaggerated response prompts the United States audience to fully understand what their Mexican neighbors have to deal with when it comes to drug gangs.

One of the best political cartoons that discusses the drug issue in Mexico turns towards Aztec imagery to get its message across. In this example, “Drugs” —

portrayed as an Aztec priest—raises a knife and is poised to sacrifice “Mexico.”¹⁰⁹ One thing that was noticeable is that while this image seems to draw from traditional imagery of how Aztec priests sacrificed victims on a stone altar at their temple to appease their gods, there is a considerable pigment distinction between the priest (Drugs) and the victim (Mexico). The priest (Drugs) is of darker skin coloring while the victim (Mexico) seems rather Caucasian-looking. While this difference in skin tones could be attributed this political cartoon’s black-and-white format, it is still important to look at this difference. Another possible reasoning for this skin tone difference is that this pale Mexico represents either the United States interest in Mexico or to create sympathy to the stereotypical Caucasian, United States citizen with their Mexican counterparts. Regardless of this intended tone, this political cartoon perpetuates the idea that the Aztec senselessly sacrificed victims much like how drugs senselessly destroy lives.

Unlike the majority of political cartoons used in this research, the following political cartoon is the only one that was published in a Mexican paper. In this political cartoon, Uncle Sam is shown snorting cocaine and is thinking “*Están locos si piensan que no voy a meter mis narices en el tema del naco Mexicano*” or roughly translated as “They are crazy if they think I am not going to put my nose in the issue of Mexican drug traffickers.”¹¹⁰ By exploring this example, it would appear that Mexico views the United States as having a large nose that should not be putting itself into Mexican politics because the United States has a drug addiction. Therefore, the United States as a whole are shown to be incapable of helping with the issue of drug trafficking based upon the large number of drug users in the United States.

Mexico is shown to be a victim where the drug violence affects everyone. In one political cartoon, the Mexican flag is shown but the eagle that usually stands proud on its cactus is shown shot and bleeding.¹¹¹ By showing the Mexican flag shot up and the eagle dead the political cartoonist is arguing that the drug violence affects and hurts everyone. The United States equivalent would be if Uncle Sam, the Statue of Liberty or the bald eagle were shown dead from a gunshot wound.

In the final political cartoon that demonstrates the drug trafficking issues in Mexico, the artist plays on “El Grito,” or the traditional Independence Day yell. The outline of Mexico is shown to be crying out “Help!”¹¹² While “El Grito” is usually a celebratory yell in honor of Mexico’s Independence, this political cartoon indicates that since there is a large amount of violence resulting from drugs, “El Grito” should be changed to one of fear. Thus, Mexico is not portrayed as a vicious drug cartel member ready to gun down Mexican or United States citizens, but as a victim of this activity which needs assistance.

Each of these political cartoons provides small dots that viewers can connect to form a larger image. While seemingly insignificant at first, they—like comic books—show how “crucial [it is] to understand how the United States public ‘sees’ Mexico.”¹¹³ These sources are not merely examples of concepts “ingrained in the American psyche,” they demonstrate how the idea of “Anglo superiority” is now “drawn upon for parody” and plays on the news coverage to portray events in a quick, humorous way.¹¹⁴ But, as with any analysis, the context of where the political cartoons and comic books come from must be considered when analyzing their sources, namely historical events and policies between Mexico and the United States.

When looking at relatively modern history of Mexico, the start of influence in comic books and political cartoon can be traced to issues that began in the 1960s. In the 1960s, the unemployment rates in Mexican cities “rose to 40 percent.”¹¹⁵ While this problem directly affected Mexico, the United States was also “concerned about the potential political instability and social problems created by the situation.”¹¹⁶ To alleviate any and all related problems, Mexico and the United States created the Border Industrialization Program, also known as *maquiladora*, which would “permit American companies to build assembly plants in Mexico employing cheap Mexican labor.”¹¹⁷ While this situation helped to resolve the unemployment issue in Mexico, it also set the stage for the issue between illegal immigrant workers in the United States as well of Mexican citizens “stealing” jobs when American companies relocate to Mexico. This also laid the foundation for comic books to incorporate Mexico in their creations.

After the initiation of *maquiladoras*, the 1970s brought Mexico into the world’s energy scene. Mexico was especially important to the United States as the United States was making “the energy problem” “an area of top national priority” as Mexico is a source of energy through its production of oil.¹¹⁸ Given the importance Mexico would have to the United States, it would make sense how Quetzalcoatl would be shown as an important character in the 1982 issue of *Thor*. In general, the United States would need to be in Mexico’s favor so that the United States would be able to receive energy from Mexico.

The 1980s brought out another side for Mexico, much like how Tezcatlipoca is another side of Quetzalcoatl. After being well-loved in the United States for as a source of oil, in 1982, it became extremely clear that “Mexico’s inability to pay its debt could have a profound impact on the US and international financial system.”¹¹⁹ This financially difficult situation led the United States to revise its policies in Central America during this time period.¹²⁰ Due to the financial situation, Quetzalcoatl could no longer be a partner with Thor, but a juvenile sidekick that needed to be watched.

To make things worse, 1985 brought more woes for the Mexican-United States relationship, including drug trafficking. While Mexico’s financial status worried the United States, the issue of drug trafficking became the main focus for the United States. These issues seemed to replicate the Aztec’s love for duality as Mexico had been “the *source* of a high-priority problem” as well as “a potential *solution* as well.”¹²¹ Mexico was both a friend and an enemy, and was thus examined from both sides of this image. This complication could explain why the 1984 issues of *Wonder Woman* chose to look at Tezcatlipoca in a negative light a mere two years after *Thor* had hailed Quetzalcoatl’s valor. The *Wonder Woman* comic books show how public opinion towards Mexico shifted to unfavorable in the eyes of the United States.

With the changing situations occurring in the real world, comic books also showed signs of the new decades. While *Wonder Woman* and *Thor* demonstrated racial diversity in their comic books by having Tezcatlipoca, Quetzalcoatl and other sun gods, respectively, this is also in line with how DC and Marvel Comics were starting to create “psychologically complex characters: racial, gender, ethnic, and sexual concerns entered into the mainstream fray.”¹²² In this way, comic books created in the 1980s and 1990s in the United States

were not only favoring the country's international neighbors but also the diverse culture of the United States. Essentially, the comic book universe was starting to become as realistic as the readers'.

After the attention Mexico had received from its energy production, financial troubles and drug trafficking during the early and mid 1980s, the United States' media coverage declined towards the end of the 1980s. The news coverage after 1987 "declined in volume and moderated in tone" compared to prior years.¹²³ This could be attributed to "Latin America's emerging self-confidence" which is represented by the fact that an "eight-nation Latin American summit" was held in November of that year without "Washington's blessing."¹²⁴ Instead of relying on other countries' support, Mexico and other Latin American countries were telling the world's "superpowers to 'leave us in peace.'"¹²⁵ As Latin America worked on making their region an independent area, the United States shifted its attention elsewhere. Not only was the news coverage void of Mexican stories, so were comic books without Mexican-influenced stories as the last one published was *Wonder Woman #316* in 1984 and the next comic book to really discuss Mexico would not be published until *Aztek: The Ultimate Man #1* in 1996. This relationship shows that when the news does not cover Mexico, the comic book industry does not either.

Perhaps one of the most important years in the 1990s in regards to public opinion in both the United States and Mexico was 1991. In 1991, the "five-hundredth anniversary, or quincentenary" honoring Christopher Columbus's so-called discovery of the Americas was held.¹²⁶ This celebration angered some indigenous groups in both Mexico and the United States as they felt that Columbus should not be honored for discovering their homeland. Likewise, the history taught about this subject was usually skewed in such a way that the indigenous people were barbarized, while Columbus was honored. After the outcry over this celebration, historians began to reexamine the history that they had written and been taught to truly understand the full story. While looking back at comic books created with this new research feeling in mind, Bentley Boyd's *Exploring the Americas*, released in 2007, works to fix the flawed thinking associated with history.

1994 was a year of special note as the North American Free Trade Agreement, or NAFTA, was signed. The NAFTA agreement was signed between Mexico, Canada and the United States and was created to increase trade and thus the economy of those involved.¹²⁷ The United States and Canada seemed to have the better end of the deal as Zapatista revolts began in "the Chiapas region of Mexico" later that same year.¹²⁸ The Zapatista revolts were conducted as the group felt that Mexico was short-sighted in signing the NAFTA agreement because Mexico received fewer benefits when compared to Canada and the United States. Four years later, the United States' presidential elections would focus almost all of its attention on Mexico—with the exception of "the Central American crisis."¹²⁹ After being essentially overlooked, Mexico was starting to become an area of interest in the United States due to the NAFTA agreement.

This feeling of the United States overseeing Mexican affairs and its well being, such as the NAFTA agreement, could be a reason why *Superman Annual #12*, published in 2000, contained the story line that it did. As the United States

began reexamining the importance of their southern neighbor, Superman was helping out three Mexican superheroes. Superman stepping and helping the Mexican superheroes save the day is similar to the United States stepping up and helping Mexico fulfill economic goals. This parallel imagery between real-life examples and those found in comic books seems to show the American public ready to help take care of Mexico for the benefit of the United States.

As the first decade after 2000 recently drew to a close, it may still be too early to understand all of the historical events that shaped comic books. However, while examining political cartoons and their accompanying news stories, there appears to be an increase in drug violence that is reminiscent of the 1980s. Along with this, Mexican immigrants were severely criticized (or praised) for the jobs that they are said to steal (or accept) from United States citizens. While also taking into consideration other cultural creations, namely movies, Mexico was shown to have been filled with savage people from films like *2012* or *Apocalypto*. This insensitive portrayal has been done before and has also been known to be reversed.

Much like history, comic books are also dictated by their own historical events and time periods. Similar to how students in world history classes need to have a grasp on how past events shaped current ones, by the 1970s, the Marvel Comics company was publishing comics that “had a past, present and future” which required “fans [to] have knowledge of hundred of years of events to completely appreciate the Marvel universe and its continuity-based realism.”¹³⁰ This was not done at the whim of the comic book creators, but proved to be a necessity as Marvel Comics “claimed that its comic books were traditionally realistic by reflecting the world in which the creators and readers lived.”¹³¹ In this way, history was not only merely recorded and shaped the real world but also the fictional characters in Marvel Universe. This shows how intertwined history and pop culture can be.

Since history, comic books and political cartoons have been teaching historical events and retelling stories from the past for well over thirty years, it is clear that this trend will continue. This changing bond can be seen as “blatantly racist and derogatory minority stereotypes” are no longer the norm in cartoons published in newspapers and how these minority characters have grown from being on the “receiving end of physical and verbal abuse” to powerful characters that can save the world.¹³² Where history is said to repeat itself, so do the names like Quetzalcoatl—once frequently used to invoke power, only to be forgotten—reappear with new life in “artistic, literary, and even social applications.”¹³³ Nothing about history is truly forgotten, it only sleeps until it is rediscovered for a new generation.

Out of all the sources examined in this research, it is safe to assume that while comic books and political cartoons are not always the most authoritative sources, they nonetheless provide invaluable information. These resources are created not to retell indisputable events for future generations, but to entertain and, particularly with political cartoons, stimulate thought. In this simple gesture of entertainment and fun these resources show the United States’ true feelings in regard to Mexico. When the news between these two countries is calm, comic books show Mexico, Mexican superheroes and cultural icons in a pleasant light. Likewise, political cartoons focus on other, more

pressing issues. However, when the news becomes tense and the countries' relationship is strained, the opposite occurs. History textbooks present facts, but these sources reveal the shifting nature that makes up public opinion. Accordingly, comic books and political cartoons can show how the general public of the United States responds to changes of government policies concerning Mexico.

Notes

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2. Ibid, 168.
3. John H. Coatsworth and Carlos Rico, *Images of Mexico in the United States* (San Diego: University of California, 1989), 11.
4. Ibid, 11.
5. Larry Gonick, *The Cartoon History of the Modern World Part 1: From Columbus to the U.S. Constitution* (New York: Collins, 2007), 5 and 16.
6. See Figure #1.
7. See Figure #2.
8. See Figure #3.
9. See Figure #3.
10. See Figure #3.
11. See Figure #4.
12. See Figure #5.
13. See Figure #6.
14. See Figure #7.
15. See Figure #8.
16. See Figure #8.
17. See Figure #8.
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19. See Figure #9.
20. See Figure #10.
21. Pacific Lutheran University. "Quetzalcoatl: 'The Feathered Serpent.'" Accessed October 1, 2010. <http://www.plu.edu/~westgale/quetzalcoatl/home.html>.

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24. Florescano, *The Myth of Quetzalcoatl*, 1.
25. *Ibid*, 1.
26. *Ibid*, 1.
27. See Figure #11.a.
28. See Figure #11.b.
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37. John H. Coatsworth and Carlos Rico, *Images of Mexico in the United States* (San Diego: University of California, 1989), 114.
38. Casey Joe (w), Keith Giffen (w), Jim Muniz (p), and Cam Smith (i). "The Breaks." *The Last Defenders #2* (June 2008), Marvel Publishing, INC, 6.
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43. Pacific Lutheran University, "Tezcatlipoca: 'Smoking Mirror.'" Accessed October 1, 2010. <http://www.plu.edu/~westgale/tezcatlipoca/home.html>.
44. Guilhem Olivier, *Mockeries and Metamorphoses of an Aztec God*, trans. Michel Besson (Boulder: University of Colorado, 2003), 49.
45. Kay Almere Read and Jason J. Gonzalez, *Mesoamerican Mythology: A Guide to the Gods, Heroes, Rituals and Beliefs of Mexico and Central America* (New York: Oxford University Press, 2000), 250.
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48. Ibid, 49.
49. See Figure #17.
50. See Figure #17.
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52. See Figure #18.
53. See Figure #19.
54. See Figure #20.
55. See Figure #20.
56. See Figure #21.
57. See Figure #22.
58. See Figure #23.
59. See Figure #23.
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63. See Figure #25.

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71. See Figure #28.

72. See Figure #29.

73. See Figure #29.

74. See Figure #30.

75. See Figure #30.

76. See Figure #31.

77. See Figure #32.

78. See Figure #32.

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80. See Figure #33.

81. See Figure #34.

82. See Figure #35.

83. See Figure #35.

84. See Figure #36.

85. See Figure #37.

86. See Figure #37.

87. See Figure #38.

88. See Figure #39.

89. See Figure #39.

90. See Figure #40.

91. See Figure #40.

92. See Figure #41.

93. Jorge I. Domínguez and Rafael Fernández de Castro, *The United States and Mexico: Between Partnership and Conflict* (New York: Routledge, 2001), 151-152.

94. See Figure #42.

95. See Figure #42.

96. See Figure #43.

97. See Figure #44.

98. See Figure #45.

99. See Figure #46.

100. "Welcome to the DREAM Act Portal." *DREAM Act Portal*. 2010. Accessed December 27, 2010. <http://dreamact.info/>.

101. See Figure #47.

102. See Figure #48.

103. See Figure #49.

104. See Figure #50.
105. See Figure #50.
106. See Figure #51.
107. See Figure #52.
108. See Figure #52.
109. See Figure #53.
110. See Figure #54.
111. See Figure #55.
112. See Figure #56.
113. John H. Coatsworth and Carlos Rico, *Images of Mexico in the United States* (San Diego: University of California, 1989), 6.
114. Ibid, 112.
115. Ina Rosenthal-Urey, *Regional Impacts of U.S.-Mexican Relations* (San Diego: University of California, 1986), 33.
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117. Ibid, 33.
118. John H. Coatsworth and Carlos Rico, *Images of Mexico in the United States* (San Diego: University of California, 1989), 7.
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121. Coatsworth, 7.
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129. Coatsworth, 4.
130. Matthew Pustz, *Comic Book Culture: Fanboys and True Believers* (Jackson: University of Mississippi, 1999), 52.
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APPENDIX: FIGURES 1-56

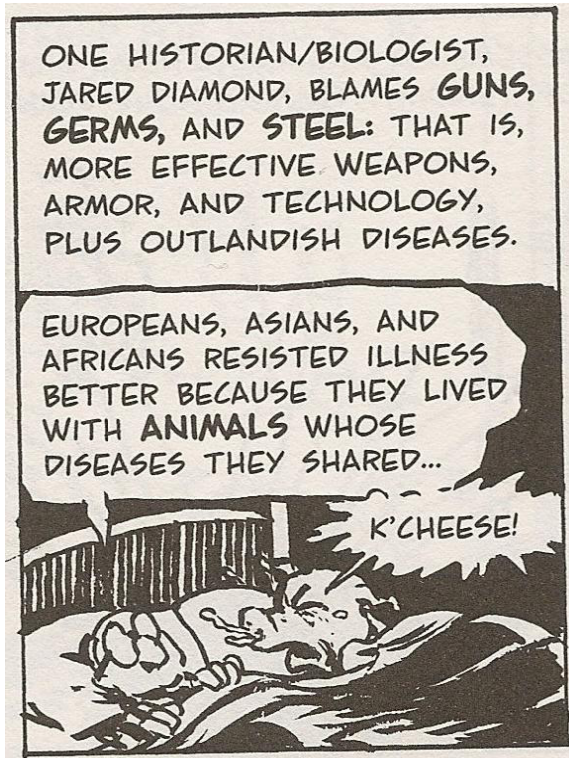


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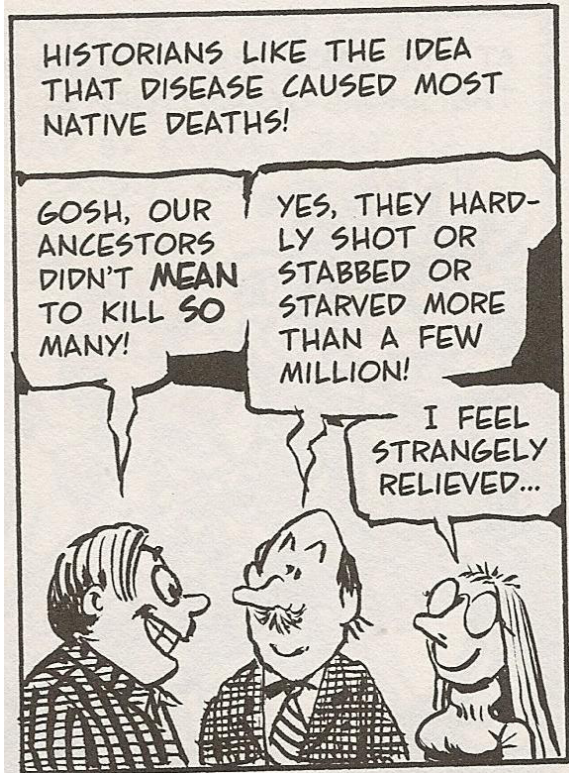


Figure 2

HOW DO WE COME TO TERMS WITH WHAT HAPPENED IN MEXICO? HISTORY IS SUPPOSED TO **REPORT STORIES**; TO SEEK **CAUSES** AND **EFFECTS**; TO ASSESS, WEIGH, ANALYZE... BUT CAN HISTORY **JUDGE**? DECIDE FOR YOURSELF... BUT I ASK YOU, **HOW ELSE CAN WE REACT** TO WHOLESALE MURDER, OPPRESSION, AND THE DESTRUCTION OF A CIVILIZATION'S CULTURAL MASTERPIECES? MAYBE WE CAN SAY THE DESTROYERS WERE A PRODUCT OF THEIR TIME... BUT THEN, MAYBE WE CAN JUDGE THEIR TIME TOO... AND TRY TO MAKE **OUR OWN TIME** MORE REASONABLE AND HUMANE, AND LESS BIGOTED, BY COMPARISON.

DANG, MAN!
LIGHTEN UP!
WHAT'S DONE
IS DONE!

YEAH! WHAT CHOO GON'
DO? PUT US IN JAIL? WE
ALREADY DEAD!



NEXT:
**AROUND THE
WORLD!**

BY THE WAY, IN TODAY'S MEXICO, CORTÉS IS THE VILLAIN OF THE STORY, AND GUATEMOZIN, THE LAST DEFENDER OF TENOCHTITLÁN, IS THE HERO!

Figure 3



Figure 4

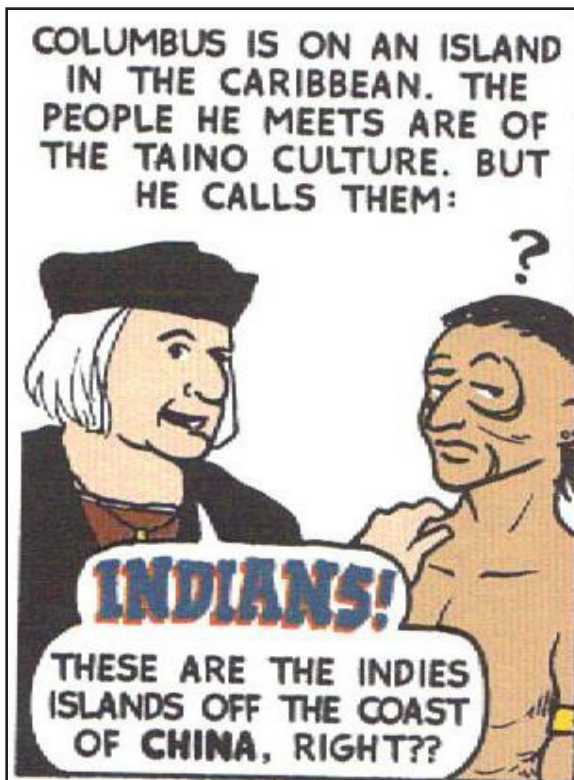


Figure 5

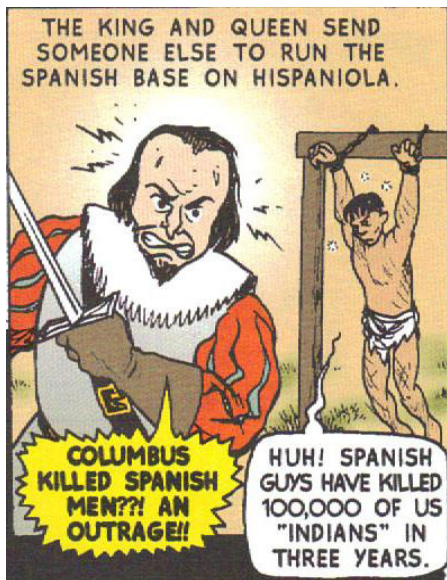


Figure 6

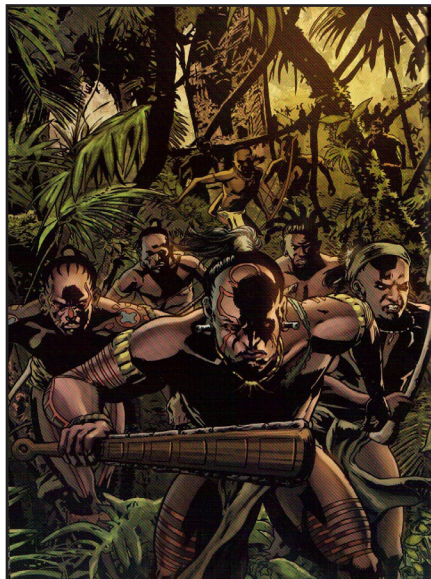


Figure 7



Figure 8



Figure 9



Figure 10



Figure 11a



Figure 11b

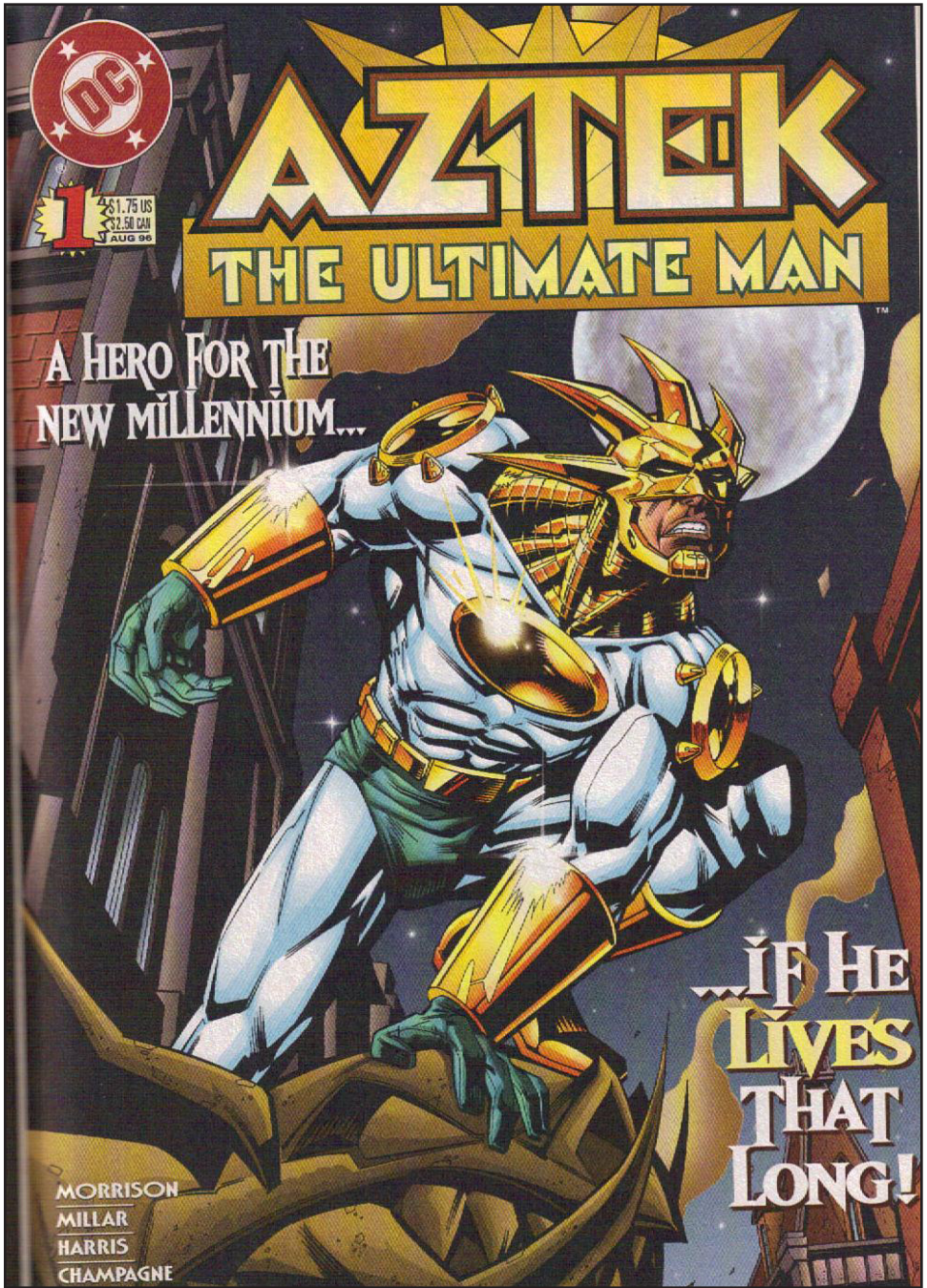


Figure 12



Figure 13



Figure 14



Figure 15



Figure 16



Figure 17



Figure 18



Figure 19



Figure 20



Figure 21



Figure 22



Figure 23





Figure 24

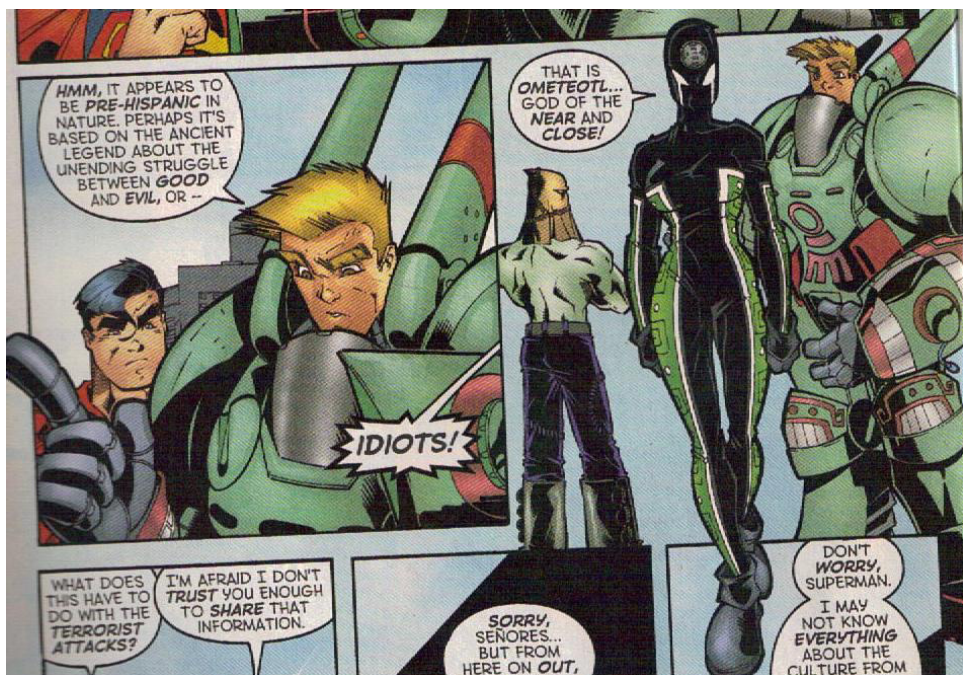


Figure 25



Figure 26



Figure 27



Figure 28



Figure 29



Figure 30



Figure 31



Figure 32



Figure 33

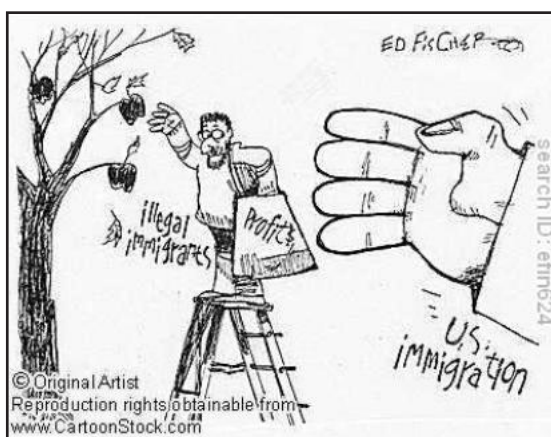


Figure 34



Figure 35



Figure 36

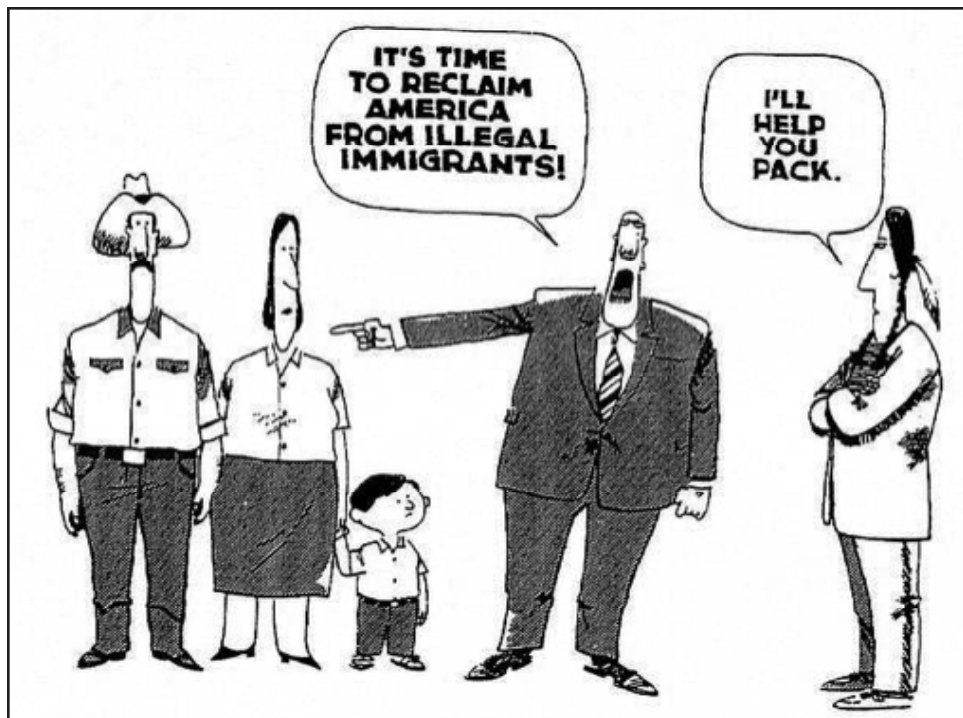


Figure 37



Figure 38



Figure 39



Figure 40



Figure 41

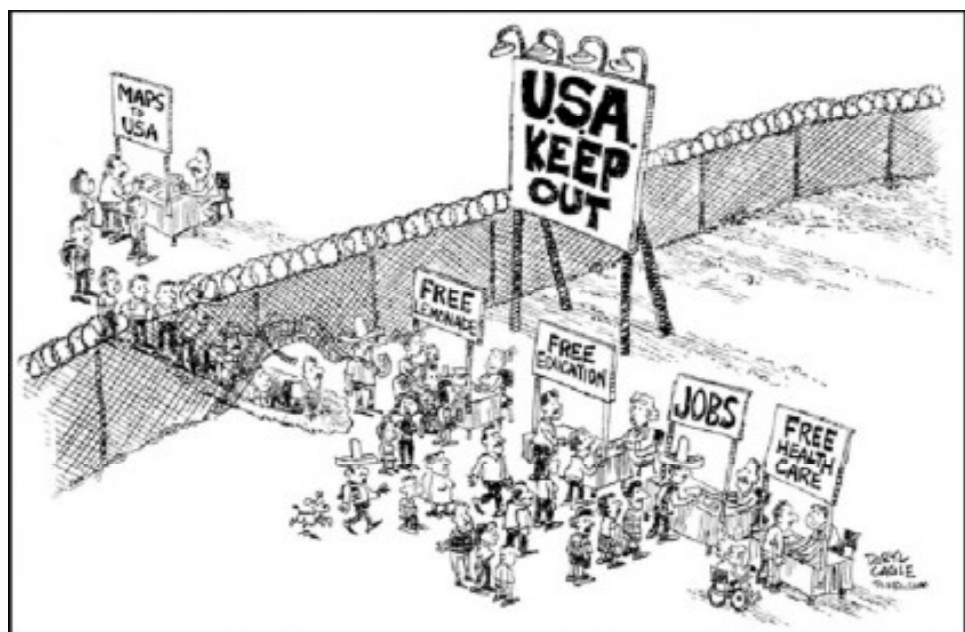


Figure 42



Figure 43



Figure 44

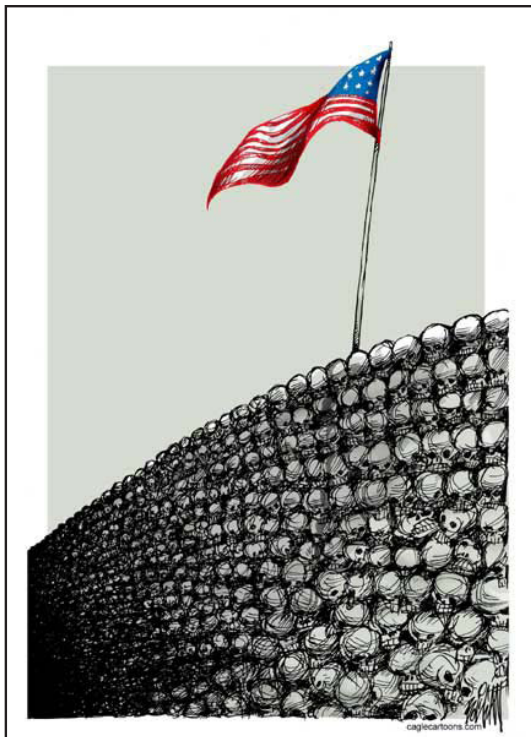


Figure 45

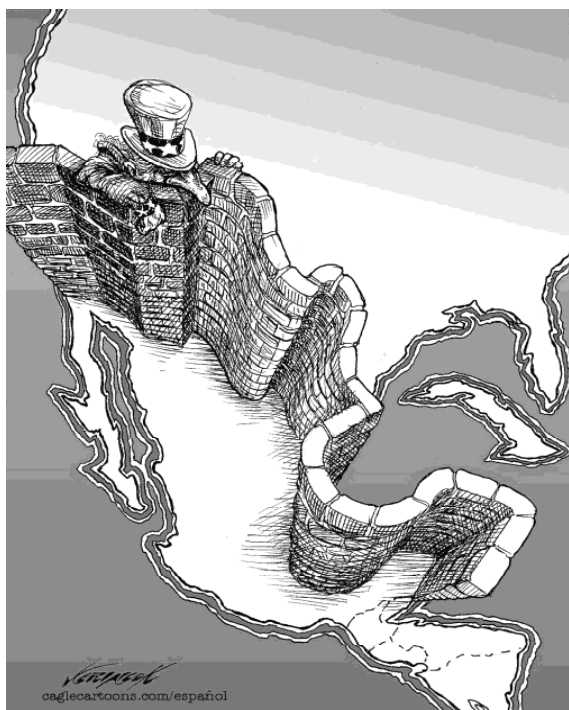


Figure 46



12-21-10 THE PHILADELPHIA INQUIRER, UNIVERSAL UOLICK.

Figure 47



Figure 48



Figure 49

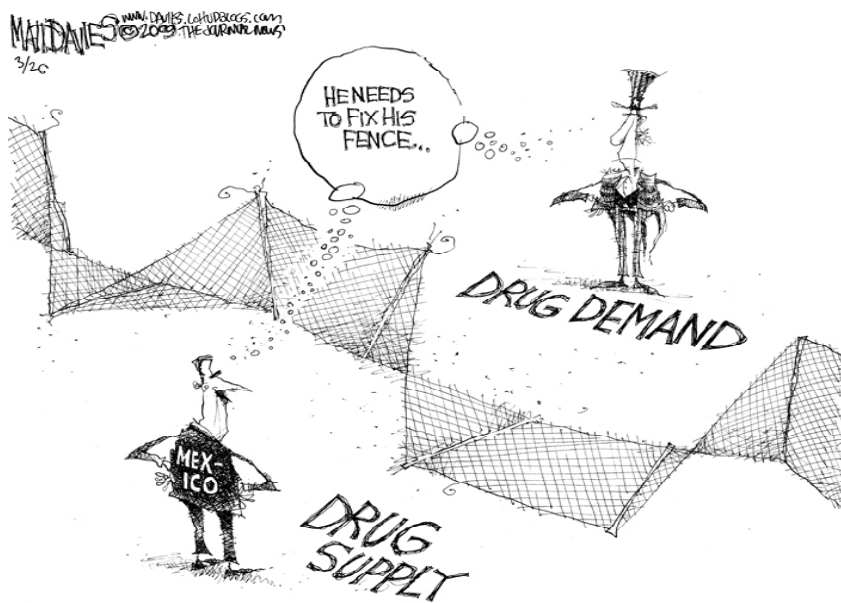


Figure 50



Figure 51



Figure 52



Figure 53



Figure 54



Figure 55



Figure 56

INTEGRATING TECHNOLOGY INTO SECONDARY ENGLISH CLASSROOMS TO SUPPORT CONTENT AREA INSTRUCTION AND 21ST CENTURY LEARNING

Emma Byrne

Increased technology use in the classroom is often emphasized in literature, professional development workshops, and even informal conversation among educators because we know it positively affects student engagement and exposes students to, if not teaches them to use, technology found in post-graduate academic and professional settings. However, typical classroom technology use often engages students passively—in PowerPoint presentations or supplemental video and audio recordings. Unfortunately, sometimes technology resources are scarce, and a single school cannot provide unrestricted technology access for all students. Additionally, mandated technology use can be perceived as an interruption to content area instruction, rather than an appropriate or complementary addition to classroom learning.

The state of West Virginia—where I conducted my research—requires teachers to include 21st Century Learning Standards (Learning Skills and Technology Tools) into their classroom instruction. These learning standards, which align with national 21st century learning and technology standards, are designed—over a four-year high school career—to facilitate (1) the development of advanced research and critical thinking skills, (2) experience in interpersonal group work and project-management, and (3) the use of emerging technologies in academic, personal, and professional work (Paine 2007, foreword). In order to satisfy the 21st Century Learning Standards objectives, teachers are required to teach at least one lesson per year from a program called TechSteps. This program offers preplanned lessons, projects, and assessment tools for teachers in many content areas and specializations, including English. Though TechSteps satisfies the requirement for 21st Century Learning Standards, many teachers I have spoken to at University High School in Morgantown, West Virginia—where I conducted my research—perceive the TechSteps requirement as cumbersome and disconnected from their curricula. In fact, only two of the English/language arts instructors with whom I work had created accounts with Techsteps by the end of the first nine-week grading period, even though instructors in English/language arts opted (through their Professional Learning Community) to use Thinkfinity, a digital collaboration tool, in their professional development and organizing strategies—showing that technology plays an important role in their professional work. Technology is an active part of teachers’ personal and professional lives, and I believe it should be integrated more holistically into our teaching practices.

The English/language arts (ELA) classroom already balances instruction in literature, language, vocabulary, reading, research, and writing. In the same

manner, I think instructors in ELA classrooms must also balance English content instruction with communication and writing skills inherent in technology usage, problem solving, and information management. My research explored several approaches to combine teaching 21st century skills with technology use that supports content-specific instruction in a secondary English classroom. Successful end products from this inquiry (that is, activities that successfully convey both 21st century skills and required English content) will not only satisfy a teaching requirement (integrating 21st century learning CSOs), but will also further develop my students' abilities to successfully interact with their world.

Before crafting this inquiry, I consulted research in the areas of literacy pedagogy, ELA classroom strategies, and technology integration in ELA classrooms. These resources helped me establish working definitions and create my pedagogical frameworks. Additionally, the resources were a source of advice from researchers with experience in implementing technology-rich projects into English and language arts classrooms.

Even in the field of English and language arts education, literacy is hard to define, and becomes further complicated with the addition of technology skill. In consultation of my resources, I found that definitions of literacy differ between personal, working, and public arenas of communication. That is, there are separate requirements of literacy for each area. Some authorities stress that students need access to—and practice using—emerging technologies in order to become literate in these differing literacy areas (New London Group 2000, 9-37). In support of these multiple areas of literacy, some educators suggest incorporating technologies into the classroom that students may already use outside of school (such as email, instant messaging, and cell phones), despite the critical voices claiming that such technologies bring non-standard English practices into the classroom (Sternberg, et al 2007, 416-420). Some teacher-preparation texts provide instructional and organizational strategies which support the concept of multiple literacies (including technology literacy) within the classroom, which helped inform my choice of content and technology project pairings (Chudi & Chudi 2007, Ch. 9).

Recent research in education has explored the relationship between technology skills and English and language arts instruction. For example, one study indicated that incorporating digital tools (a blog) can increase student engagement (Cleary 2008). Another article described a pedagogical framework for incorporating technology to achieve instructional goals without disrupting the classroom. This framework suggests taking advantage of the tools available within a school, teaching content through technology (rather than as a means to an end), and consistently assessing whether implemented strategies are effective (Young 2004).

These combined resources led me to create the following guiding question: In the secondary English classroom, how can I integrate technology activities to support both English/language arts instruction and 21st Century Learning Standards? Additionally, I will be exploring the sub-questions: (1) How does this pedagogical approach affect student engagement? (2) How does this pedagogical approach affect student comprehension? and (3) How can I effectively assess whether my classroom activities are addressing 21st Century Learning Standards?

For educators in West Virginia, this project is a valuable resource for integrating projects and/or assessment tools that help support 21st Century Learning and Technology Tools Content Standards—required elements of all 9-12 grade

teachers. For all ELA teachers, this project outlines ways to promote digital literacy; support skills in research, analysis, and evaluation; and develop interpersonal and problem-solving skills necessary for success in students' personal and professional lives.

My research was conducted at University High School (UHS) located just outside the city of Morgantown, West Virginia. UHS has approximately eighty-five faculty members and 1295 students. The student population is 98 percent Caucasian and 2 percent minority. Though UHS was founded in 1925, the current school facility is brand new, having officially opened in the spring semester of 2009. As a result, the school boasts state-of-the-art technology including the following: four computer labs (one portable lab of 13 laptops), a distance-learning lab, Smartboards, LCD projectors, wireless/cable Internet, and computer clusters (four or five computers) in individual classrooms. My classroom is equipped with a projector, five computers, a wireless writing tablet, and a wireless presenter. The accessibility of technology at UHS makes it an ideal location to explore best practices for integrating 21st century learning skills into ELA classrooms.

I conducted my research with students in two honors English 11 classes under the supervision of my mentor teacher, John Conrad. One class consists of twenty-one students, while the other has 15. Our class diversity ratio is 90 percent Caucasian, 10 percent minority, the minority population being slightly higher than the ratio of UHS as a whole. Many of the students are not originally from West Virginia, having moved here sometime during middle or high school (most often as a result of their parents working for nearby West Virginia University). Despite being in an honors class, the students routinely struggle with mechanics, organization, and development of ideas in writing assignments, and many students express distaste for writing in general. These are students who will most likely seek higher education after they are graduated from high school and therefore need a wide variety of skills in communication, collaboration, and technology use.

Methods

I began my research by informally discussing technology integration with my host teacher, Mr. Conrad, and other English instructors at University High School. I established the types of technology they integrate into their classrooms and their methodology for doing so. I also spent time exploring the West Virginia 21st century learning skills CSOs and deciding which CSOs best fit the 11th grade ELA curriculum. There are three areas of 21st century learning skills: (1) Information and Communication; (2) Thinking and Reasoning; and (3) Personal and Workplace. In the first area—Information and Communication—I decided to attempt the incorporation of all three sub-skill areas: research, analysis, and synthesis. In the second area—Thinking and Reasoning—I decided to incorporate just the sub-skill of critical thinking, with an emphasis on synthesis and evaluation. In the third area—Personal and Workplace—I decided to incorporate the sub-skills of working under stress, setting and achieving goals, taking ownership of learning, project planning, and goal-monitoring. Additionally, I attempted to use technology tools and applications for each project that complemented and supported the instructional goals.

The first project students completed was an introductory presentation for Olaudah Equiano, the author of a slave narrative. I separated students into groups and gave each group specific information to find on the Internet. Then, students compiled their findings in a PowerPoint presentation, saved the presentation correctly on the school network, and emailed it to me so I could compile the presentations as one file. All of this happened during one class period in the computer lab. The next day, students had five to ten minutes to prepare for their presentation. Each group elected a spokesperson or the members collaborated to explain the information on their slides.

The next project involved an independent reading project. Students selected a 200-page novel from the library (or brought one from home) and read it over four and a half weeks. Students had a set amount of pages to read and 5 “double-entry journal” entries due each week. In theory, double-entry journals facilitate text-to-self connections and give students practice in responding to source information, like data in a research paper. Students select pieces of text in a novel that they find interesting or evocative. Then, students quote that selection in a journal and write a personal response by drawing a connection, citing another example, asking questions about the text, or making predictions about the selection. Students also had to complete a final project for their independent novel, which included a written component and a creative presentation component, each worth forty points. Students could choose from a wide range of written projects (such as newspaper article, letter to a character, or research report) and creative presentations (such as a book talk, PowerPoint, movie trailer, dramatic reading, or artistic project). A few days after introducing this project, students wrote proposals outlining the following: their chosen project option, any necessary equipment, and a description of how they would like to be graded. After students had completed the proposal, I gave them a rubric with categories that reflected my assignment goals and the students’ stated preferences for grading. Then, I explained that students could weight certain categories to reflect the strength of their project. Students had two weeks to work on the projects; presentations took place over three class days.

The next project utilized iPads for classroom research. Before starting to read a selection on the Declaration of Independence, I had students look up information on Thomas Jefferson. They could only use their book or a website I provided (which they accessed on their iPad), but they were encouraged to decide which source was more appropriate for finding the information. After finding the required information, students had to synthesize the information into a mini biography. Additionally, students looked up definitions and examples of the literary terms *cadence*, *parallelism*, and *rhythm* for an upcoming quiz.

The final project was an editorial piece written on a self-selected topic. First, students read example editorials and evaluated them based on knowledge of rhetorical appeals and written mechanics. Then, students used iPads to access the “Points of View” database on EBSCOhost (accessed through UHS library services). Students researched potential topics and kept track of resources by sending them through EBSCOhost to a class email account set up through Google’s Gmail. Then students decided on a topic and wrote a first draft in class using data sources from research. Then students typed the editorials and saved them (using this format: Last Name_Editorial_2010.doc) on their student files and Edline (an online space where students, teachers, and parents can access grades, assignments, and

class announcements). The next day, we uploaded the files onto GoogleDocs and students downloaded a peer's editorial (and immediately saved as: Reviewer's_LAST NAME_REVIEW_ORIGINAL_Last Name_2010.doc) and completed a peer review by utilizing the 'track changes' function and adding comments. Then students finalized their editorials based on peer edits and comments. Finally, students presented the editorials in class. Each student used a scoring sheet during presentations to score the editorials from 1-5 (1=okay, 5=excellent) and to make comments on the presentations.

Data Sources and Collection

The two most consistent sources of data were my reflections and classroom observations that either my host teacher or I completed while students were working. During the observations, we tallied the number of times I had to redirect the class to be on task, the number of on and off-task questions, the number of on and off-task side conversations, and any significant student comments I heard during the activity. I also recorded my own thoughts during or immediately after the activity.

For all activities (except the initial author PowerPoint presentation) students completed a survey, which asked them to reflect on the ELA content area skills and 21st Century Learning Standards skills they either learned or practiced during the activity (See Appendix A). Students checked off whether they learned or practiced individual skills and then rated the change in their abilities for these skills sets on a Likert scale, which asked students to indicate their own change in abilities for the selected skill set as none, slight, moderate, or great. The survey also had room for student comments. Additionally, I pulled four students from each class for a focus group conversation in which I asked them general questions about their enjoyment of the project, their stress level, their technology use, and changes they would make for the future. For the focus group, I pulled a one high-achieving student (consistently scored As on assignments) one middle-achieving student (consistently scored Bs on assignments), one low-achieving student (consistently scored Cs or Ds on assignments), and one randomly-selected student.

Beyond those data sources, I kept track of student grades and collected examples of student work for each project including: student proposals, written projects, creative work, and graded rubrics. Additionally, I kept track of the completion rate for activities that were connected to my research, but did not receive formal grades.

Data Analysis

For each activity, I completed two classroom observations: one in my third-period honors class and one in my sixth-period honors class. I separated the data by activity (i.e. historical background activity or rough draft writing), then respectively added together the recorded questions, comments, and redirects from each observation to determine a sum for each data point. Then I divided the sum total by two (the number of observations for each activity) to establish an average number for each data point.

In the survey, I analyzed my data by tracking the number of students that cited each skill category. I added the number of check marks for each category to determine a sum total, then divided the sum by the total number of returned surveys (for the individual activity) to determine a percentage for each category. Then, I established percentile ranges to describe the data. The learning or practice of individual skill categories was deemed 'high' in a particular activity if 75-100 percent of students reported that they learned or practiced (used, in other words) said skill. The learning or practice of skill categories was deemed moderate with 50 to 74 percent of students reporting use, slight with 25 to 49 percent reporting use, and low if 24 percent of students or less reported use. In the Likert scale, I simply recorded the number of students in each category of skill level change.

In the survey comments and focus groups, I coded my data along the following themes: enjoyment, learning, technology usage, frustration, and suggested changes. I coded my reflections and observations along the following themes: student engagement, process of work, and understanding.

Findings and Discussion

During the classroom observation of the historical background PowerPoint project, there were an average of 9.5 on-task and 3.5 off-task questions; there was an average of 7.5 on-task and 6 off-task side conversations. The students were redirected to concentrate on their work an average of two times per class period. With the time allotment of one day's class period in the lab and five-to-ten minutes of the next day's period, 82 percent of students (twenty-three of twenty-eight students) finished their work on time. The average score for this assignment was 100 percent (15/15 points). Students did not complete surveys for this activity.

In debriefing this assignment, students commented that they felt rushed to complete the project in one class period. Students generally liked the project and had fun looking up the information on the historical background and author by themselves, rather than reading it in a book. In my comments, I wrote that the project directions were fairly open, which resulted in creativity for some groups and confusion for others.

During classroom observation of the author biography research activity, there was an average of 6.5 on-task and 1 off-task questions; there was an average of 3.5 on-task and 1.5 off-task side conversations. The students were redirected to concentrate on finishing their work an average of two times per class period. In the time allotment of one class period, 84 percent (twenty-six out of thirty-one) of students finished their work on time. The average score for this assignment was 99.6 percent (14.94/15 points.)

In the surveys, students reported whether they "learned or practiced" skills in the English content area and/or in 21st Century Learning Standards. The following table (Table 1) displays the number of students (out of twenty-three) reporting learning or practicing skills in the English Content Area.

Table 1. ELA Skill Set Report for iPad Author Biography Project

Skill	Number of students	Percentage (out of 23)
Reading	20	86.95
Brainstorming	4	17.39
Writing	18	78.26
Editing	6	26.08
Publishing	2	8.69
Researching	22	95.65
Vocabulary	18	78.26
Grammar/Mechanics	3	13.04
Verbal Communication	1	4.34
Listening	2	8.69

The table displays that there were high levels (75 out of 100 percent) of learning or practice in reading, writing, researching, and vocabulary. There were no moderate levels (50 to 74 percent) of learning reported. There were slight levels (25 to 49%) of learning or practice in editing, and low levels (0 to 24 percent) of learning or practice in brainstorming, publishing, grammar/mechanics, verbal communication, and listening.

On a Likert scale, students reported their perceived change in their abilities (whether abilities increased or not) for reported skills. In the above skill set, five students reported no increase in abilities; thirteen students reported a slight increase in abilities; four students reported a moderate increase; one student reported a great increase (See Fig 1).

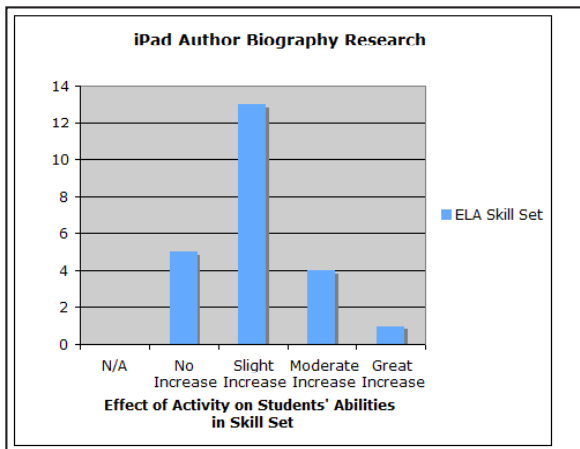


Figure 1

The following table (Table 2) displays the number of students (out of twenty-three) reporting learning or practicing skills in the 21st Century Learning Standards.

Table 2. 21st Century Learning Skill Set Report for iPad Author Biography Project

Skill	Number of students	Percentage (out of 23)
Setting a Goal	3	13.04
Finding and Accessing Info.	22	95.65
Working Under Stress	5	21.73
Using the Internet	21	91.30
Using Technology	21	91.30
Managing Work	10	43.47

The table displays that there were high levels of learning or practice in finding and accessing information, using the Internet, and using technology. There were slight levels of learning or practice in managing work, and low levels of learning or practice in working under stress and setting a goal. On a Likert scale for the above skill set, four students reported no increase in abilities; sixteen students reported a slight increase in abilities; three students reported a moderate increase and zero students reported a great increase (See Fig 2).

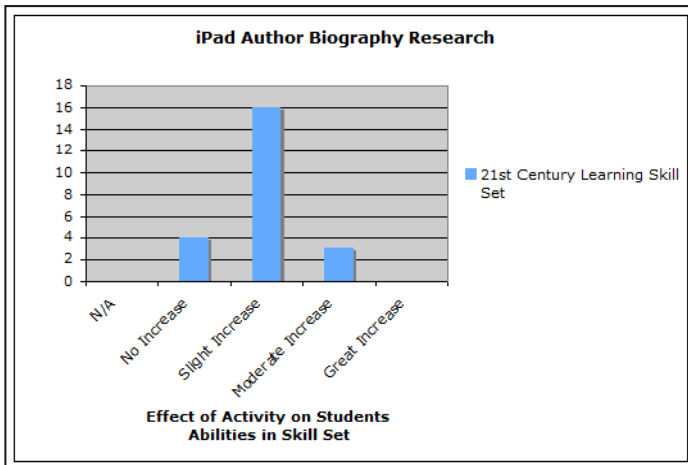


Figure 2.

In the comments section of the survey and during our focus group, students commented that they liked reading about the author from online sources instead of in the book. They enjoyed using the iPads; some students commented that they were already familiar with the device, while others commented that the devices were unfamiliar. I commented that there was no significant technology instruction time needed because students were mostly familiar with the technology or picked it up quickly. Students were very quiet and calm through the activity: I could address questions without disturbing the rest of the students because they could continue to work independently. I also commented that students seemed pressured to finish their work in one class period, but they were handling the stress with no complaints.

During classroom observation of students working on their independent novel projects, there was an average of 13.5 on-task and 5.5 off-task questions; there was an average of 6.5 on-task and 20 off-task side conversations. The students were redirected to concentrate on finishing their work and average of 4 times per class period. The

average score for this creative portion of this assignment was 90.87 percent (36.35/40 points) while the average for the written portion was 96 percent (38.4/40 points).

The following table (Table 3) displays the number of students (out of twenty-two) reporting learning or practicing skills in the English Content Area.

Table 3. ELA Skill Set Report for Novel Project

Skill	Number of students	Percentage (out of 22)
Reading	14	63.63
Brainstorming	13	59.09
Writing	18	81.81
Editing	13	59.09
Publishing	5	22.72
Researching	4	18.18
Vocabulary	2	9.09
Grammar/Mechanics	9	40.90
Verbal Communication	19	86.36
Listening	7	31.81

The table displays that there were high levels of learning or practice in writing and verbal communication. There were moderate levels of learning or practice in reading, brainstorming, and editing. There were slight levels of learning or practice in grammar/mechanics and listening, and low levels of learning or practice in publishing, researching, and vocabulary.

On a Likert scale for the above skill set, two students reported no increase in abilities, nine students reported a slight increase, eight students reported a moderate increase, and three students reported a great increase (See Fig. 3).

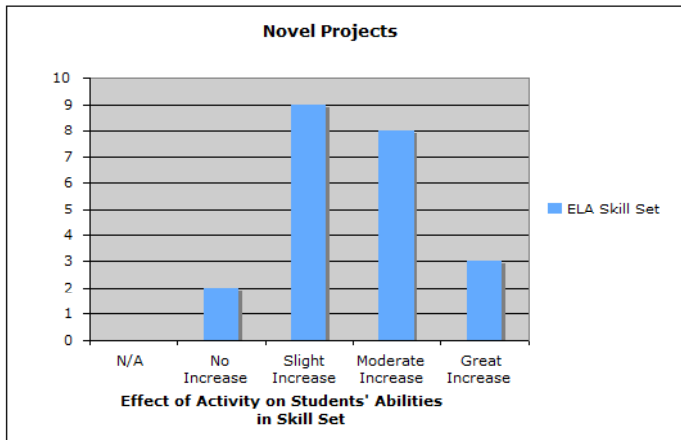


Figure 3.

The following table (Table 4) displays the number of students (out of twenty-two) reporting learning or practicing skills in the 21st Century Learning Standards.

Table 4. 21st Century Learning Skill Set Report for Novel Project

Skill	Number of students	Percentage (out of 22)
Setting a Goal	10	45.45
Finding and Accessing Info.	8	36.36
Working Under Stress	11	50
Using the Internet	9	40.9
Using Technology	10	45.45
Managing Work	19	86.36

The table displays that there were high levels of learning or practice in managing work. There were moderate levels of learning or practice in working under stress. There were slight levels of learning or practice in setting a goal, finding and accessing information, using the Internet, and using technology. There were no low levels reported. On a Likert scale for the above skill set, five students reported no increase in abilities, five students reported a slight increase, six students reported a moderate increase, and five students reported a great increase (See Fig 4).

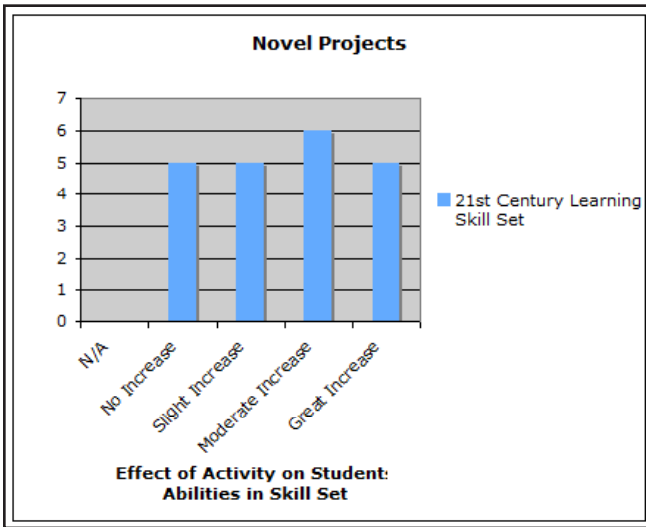


Figure 4.

In the comments section of the survey and during our focus group, students generally commented on how much they enjoyed the project. Students liked the openness of the assignment and said they felt comfortable being creative. They liked picking out their own novel and then selecting a type of project that would fit well with their book. They liked being able to weight their rubric for their particular strength. Some students felt that a two-page written project was too long; others said they easily wrote more than two pages. Some students commented that they wanted more time to work on their projects. Individual students wrote the following comments on their surveys: "I feel like now I can work better under stress;" "I feel my comprehension increased because of the project;" "This project makes you WANT to read books;" "I learned how to work with video and internet clips;" "I felt good about accomplishing my goal and getting my work done." In regard to working on the projects in class, I commented that

students were working at different paces; therefore, when they attempted to gauge their progress by speaking with a peer, they had difficulty finding common ground in the project and quickly got off-task. In regard to their creative presentations, I commented that the presentations were very diverse. I observed that many students simply summarized the books while showing their project, while a few students analyzed characters or themes and showed that analysis through their project.

I completed three observations of class periods dedicated to working on the editorial. The first observation took place when students were using iPads to find topics and resources for their editorials; the second took place when students were in the computer lab writing their rough drafts; the third took place when students used GoogleDocs to complete a peer review of the editorials. During the observation of the iPad research activity, there was an average of thirteen on-task and one off-task questions; there was an average of three on-task and five off-task side conversations. The students were redirected to concentrate on finishing their work an average of four times per class period. In the time allotment of one class period and the rest of the day until midnight, 53 percent (twenty-four out of thirty-six) of students completed the assignment of finding a resource and successfully sending to the class email account.

During classroom observation of the rough draft writing, there was an average of 4.5 on-task and 7 off-task questions; there was an average of 1.5 on-task and 4.5 off-task side conversations. The students were redirected to concentrate on finishing their work and average of three times per class period. In the time allotment of one class period, 72 percent (twenty-six out of thirty-six) of students finished typing a rough draft from their outline.

During the classroom observation of students using GoogleDocs to complete a peer review, there was an average of thirty-seven on-task and one off-task questions; there was an average of thirty-three on-task and 13.5 off-task side conversations. The students were redirected to concentrate on finishing their work and average of 0 times per class period. In the given time allotment of one class period (and then until midnight at the end of the day), 66 percent (twenty-two out of thirty-three) of students completed on online peer review. An additional 9 percent of students (three out of thirty three) completed a hand-written peer review because some rough drafts were not accessible online (for a total peer review completion rate of 75 percent). The average score for the final draft of this assignment was 90 percent (27/30 points).

The following table (Table 5) displays the number of students (out of twenty-one) reporting learning or practicing skills in the English Content Area.

Table 5. ELA Skill Set Report for Editorial Project

Skill	Number of students	Percentage (out of 21)
Reading	12	57.14
Brainstorming	17	80.95
Writing	21	100
Editing	18	85.71
Publishing	7	33.33
Researching	18	85.71
Vocabulary	8	38.09
Grammar/Mechanics	14	66.66
Verbal Communication	19	90.47
Listening	15	71.42

The table displays that there were high levels of learning or practice in brainstorming, writing, editing, researching, and verbal communication. There were moderate levels of learning or practice in reading, grammar/mechanics, and listening. There were slight levels of learning or practice in publishing and vocabulary. There were no low levels reported. On a Likert scale for the above skill set, two students reported no increase in abilities, ten students reported a slight increase, seven students reported a moderate increase, and one student reported a great increase (See Fig. 5).

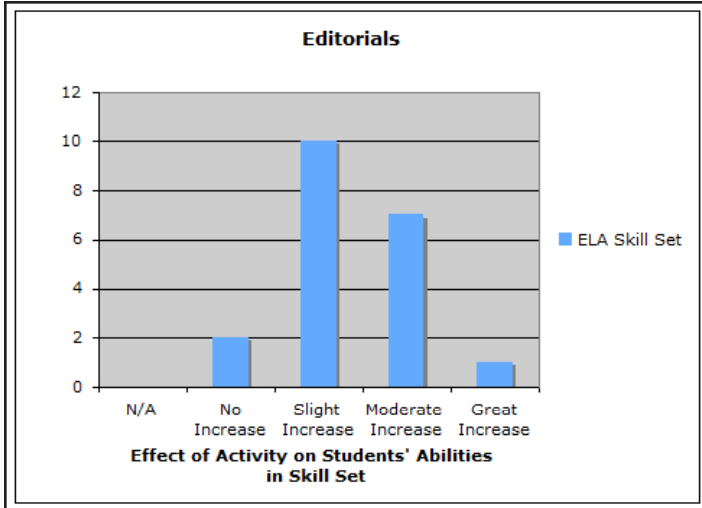


Figure 5.

The following table (Table 6) displays the number of students (out of twenty-one) reporting learning or practicing skills in the 21st Century Learning Standards.

Table 6. 21st Century Learning Skill Set Report for Editorial Project

Skill	Number of students	Percentage (out of 21)
Setting a Goal	10	47.61
Finding and Accessing Info.	18	85.71
Working Under Stress	11	52.38
Using the Internet	17	80.95
Using Technology	17	80.95
Managing Work	13	61.90

The table displays that there were high levels of learning or practice in finding and accessing information, using the Internet, and using technology. There were moderate levels of learning or practice in working under stress, and managing work. There were slight levels of learning or practice in setting a goal. There were no low levels reported. On a Likert scale for the above skill set, four students reported no increase in abilities, 11 students reported a slight increase, five students reported a moderate increase, and one student reported a great increase (see Fig. 6).

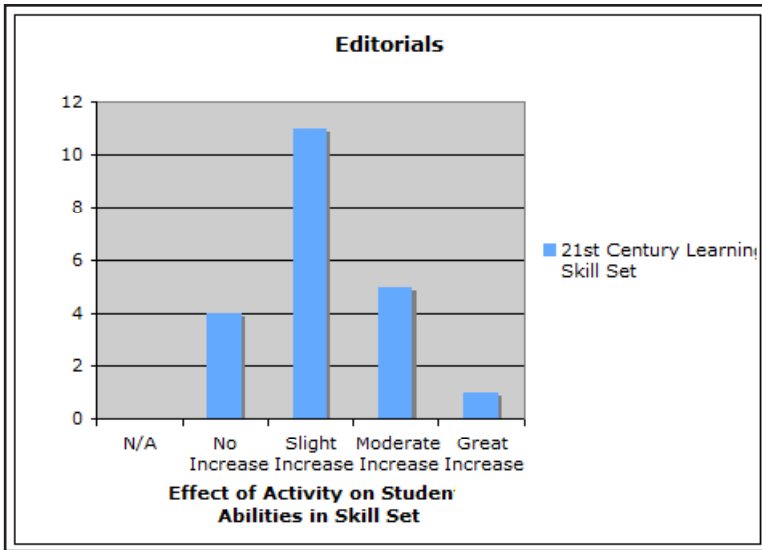


Figure 6.

In the comments section of the survey and during our focus group, students commented that this was a difficult assignment in the following areas: choosing a topic and beginning to write, reading the editorials aloud in front of class, and fitting their ideas into the editorial framework. However, they enjoyed this project for the following reasons: expressing their own opinions, doing peer review, learning new technology, and scoring their peers during the presentations. Individual students made the following comments: "I liked being able to collaborate all in one place;" "I liked the peer scoring because it mattered and we got to express what we thought;" and "The introduction of GoogleDocs really opened up a brand new resource that I can use." In regard to using iPads to find topics and resources, I commented that students "Googled each other when finished their work." In regard to writing the rough drafts, I commented that many students seemed to be a step behind and were still working on their outlines or had chosen a new editorial topic. I observed that many students from one class were commenting on the heat of the computer lab; some were discussing the best search engines to use. I also observed that students were generally quiet and attentive to their work when the temperature eventually dropped. I wrote down a comment from one frustrated student who said, "Can't we just throw this essay out the window?" In regard to using GoogleDocs, I commented that many students were collaborating with each other to learn how to use the site, and some students were discussing project-specific terms like "ethical." Other students were chatting while they waited for others' computers and web pages to load. I wrote down a comment from another frustrated student who said, "This is the hardest thing I've ever done!" I observed that after the students learned to navigate the GoogleDocs page, they worked quietly throughout the period asking questions as necessary.

Overall, I believe the data shows that all of these activities generally supported both ELA Content Standard Objectives (CSOs) and 21st Century Learning Standards. None of the activities was a failure in terms of excluding one set of skills

or the other. However, the data suggests that in the first two activities (historical background PowerPoint and Author Biography Research using iPad), the learning or practice accomplished in both skills sets happened at lower levels and with less of an increase in ability than the last two activities (novel projects and editorials). Part of this may be explained by the fact that the latter projects were larger and thus student responses reflected a greater amount of practice. However, these reported levels might also reflect that the activities that did not challenge students' abilities. However, I also want to draw attention to the stress and frustration level of students in the latter two activities. Though students cited higher levels of increased abilities for each skill set and commented on the satisfaction of completing each of these assignments, they also scored lower on these assignments and had more negative comments about the stress, work load, and time constraint. I believe this difference is significant because students should have a variety of activities in the classroom at different levels of intensity in order to meet the needs of diverse students.

In reference to my sub-question about student engagement, my findings suggest that students are actively engaged when completing novel activities in the classroom. Though my research suggests that students might have been engaged solely by the use of technology, I found that activities like working on their independent novel projects and writing up their rough drafts were days in which off-task questions and conversations dominated the class period. I believe differing paces of work caused some of this disengagement. Instead of students all exploring the same application or idea, students were working on disparate projects in disparate time frames.

In reference to my sub-question about student comprehension, I believe that comprehension was supported in all of the projects except the editorial. After grading the editorials, I noticed that the structure of students' papers did not follow the assigned outline and many had problems with grammar, mechanics, and development. I believe that the incorporation of technology in that project frustrated students and took the focus away from the basics of editorial writing. I also believe that my inexperience teaching a large writing assignment contributed to this frustration as well. Therefore, I am confident that a seasoned teacher could incorporate the technologies I used without negatively affecting student comprehension.

In reference to my sub-question about assessing 21st century learning, I believe that observation and student reflection are adequate ways to assess these skills. I actively observed 21st Century Skills taking place in the classroom during activities and students reported their skills in time management, working under stress, etc. For example, I observed students collaborating to learn and use technology applications during the GoogleDocs peer review without my prompting or interference (and, of course, recorded the number of on and off task behaviors to support this). I believe that outside the research context, educators could assess their students' 21st century learning skills through a similar (though less data-driven) teacher observation and student reflections.

Beyond exploring my research questions, I noticed an interesting trend in which students cited higher levels of learning and practice in both ELA and 21st century skill sets in projects with lower final averages. Specifically, students reported high levels of learning/practice in the independent novel project and the

editorial, though the final class average for those activities was between nine and ten percentile points lower than the historical background and iPad research activity. In my opinion, this trend suggests that students report high levels of learning/practice in activities in which they feel challenged. In the editorial and novel project, the students had to overcome obstacles like time constraints, independent work management, and unfamiliar technologies. Though students commented on the challenges of these assignments, their appraisals were overwhelmingly positive, especially in the categories of expressing their opinions, freedom to be creative, and learning skills in work management and technology applications.

Another interesting trend was the recurrence of student satisfaction in projects where the guidelines were fairly open. Over and over again, students mentioned that they enjoyed being able to express their opinions, having control over the outcome of the project, and participating in a creative process. This data not only demonstrates a student preference for ownership of assignments, but also displays a growth in the ability to select mediums of communication that are appropriate to the task at hand, which is a 21st century learning skill that I did not specifically explore in my research but is significant nonetheless.

The last piece of data I find significant is the range of abilities that students reported on their surveys. Some activities let certain students practice skills that others did not recognize or perhaps did not need to practice. Additionally, within the same activity, a comparable amount of students reported no increase in ability level and great increase in ability level. This may be caused by differing interpretations of the Likert scale categories (i.e. one student's definition of "greatly increased" is different from another's); however, it might also be caused by real differences in experience and ability level.

Conclusions and Implications for Practice

In the future, I would definitely change a number of structural aspects of each assignment. For example, I would change the approach to assignments and explicitly describe the reasoning behind each component of the assignment. I believe this would cut down on the amount of students who, for example, were unprepared to complete the GoogleDocs peer review because I had not sufficiently explained the reasoning behind having a draft available online, as well as in hard copy. However, I feel most of these structural changes are part of my own growth as a pre-service teacher and are not reflective of weaknesses in the compatibility or integration of technology and the secondary English classroom.; therefore, I am not detailing them at length in this report.

If other educators make use of my research in their own classrooms, I have some general recommendations for integrating 21st century learning skills into the classroom. First, all students should be working on a similar assignment to make the most of class time. I have observed students collaboratively brainstorming for the same project make wonderful use of their time. Yet, when I gave time in class to simply work independently on the novel projects, collaboration quickly turned into unstructured conversation. Second, always demonstrate the basic usage expectations of the integrated technology or learning tool, so that students without a working knowledge of said application or tool will feel comfort-

able, and students with such knowledge can further explore their abilities. This point in short: students are not at the same level in terms of familiarity with these skills and applications. It is important to scaffold for students without experience/knowledge without stifling those who have experience/knowledge. Additionally, I would establish a standard observation sheet for 21st century learning skills with student names down the left hand column and skills across the top. Using a form like this could be used as a pre-assessment for students during the first weeks of school; the form could also be used to assess the effectiveness of a particular unit, project, or semester in terms of teaching 21st century learning skills.

In terms of my research methodology, I would make some changes for future explorations of this topic. First, during my observations I realized that I was not consistently tracking the difference in questions/conversations about content versus questions about technology usage/21st century skills. I would make this distinction to potentially tease out imbalances in the activities. Additionally, I found that I could not compare my observation data to a classroom setting before the integration of my research project. In the future, I would establish a baseline for the classroom observations to compare any changes that occurred as a result of integrating technology and 21st century learning skills. Last, I would include test questions that tracked students' comprehension of content area knowledge learned in activities with and without the integration of technology and 21st century learning skills to determine if comprehension is affected by the integration.

Additionally, I would explore the correlation I found in high levels of student satisfaction and assignments that allowed open creativity in terms of the 21st Century Learning Skill 21C.O.9-12.1.LS2 – “Student analyzes and interprets visuals and recognizes the impact digital media influences (e.g. design, technique, and rate of speed) have on audiences. The student’s visual products reflect a sophisticated understanding of subject, digital media and design techniques” (Paine 2007, 20) and 21C.O.9-12.1.LS3 “Student creates information using advanced skills of analysis, synthesis and evaluation and shares this information through a variety of oral, written and multimedia communications that target academic, professional and technical audiences and purposes” (Paine 2007, 20) because this might be another source for project/skills to incorporate into secondary English classrooms.

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Appendix A

Name:

Activity:

Did you work in a group or as an individual?

Did you set a personal or group goal before starting this activity? Yes No (Circle One)

If yes, did you accomplish that goal? Explain:

What did you learn or practice in the areas of reading, writing, and/or communicating?

Check all that apply:

- Reading
- Brainstorming
- Writing
- Editing
- Publishing
- Researching
- Vocabulary
- Grammar/Mechanics of Writing
- Verbal Communication
- Listening Skills

On a scale of 0 - 4, how did this activity affect your ability in the skills you checked above?

0 – N/A I did not check any skills above.

1 – My abilities did not increase.

2 – My abilities increased slightly.

3 – My abilities increased moderately.

4 – My abilities increased greatly.

Comments:

What did you learn or practice in the areas of collaborating, problem-solving, and using technology? Check all that apply:

- Working in a Group
- Setting a Goal
- Finding and Accessing Information
- Working Under Stress
- Using the Internet
- Using Technology
- Managing Your Work

On a scale of 0 - 4, how did this activity affect your ability in the skills you checked above?

0 – N/A I did not check any skills above.

1 – My abilities did not increase.

2 – My abilities increased slightly.

3 – My abilities increased moderately.

4 – My abilities increased greatly.

Comments:

Thank You.

THE GLOBALIZING EFFECT OF KOREAN POP CULTURE

Jason D. Chen

The subject of globalization is typically centered heavily on the economic aspects changing the world. However, the cultural impact of globalization has also left a substantial footprint on all the nations involved in the integrated world system. Jerry Mander and Edward Goldsmith describe in *The Case Against the Global Economy* that “an intrinsic part of the process of economic globalization is the rapid homogenization of global culture.”¹ The United States is typically seen as the leading agent behind the cultural changes taking place, a role which has sparked protest and opposition. As D. Clayton Brown states, “The most vocal expressions of dissatisfaction have come from spokespersons of other countries who denounced the spread of American culture around the world.”² Accusations of McDonaldisation labeled United States’ entry into foreign lands as an act with the malevolent intentions of supplanting local cultures with American commercialism. Richard Barnett and John Cavanagh’s essay in *The Case Against the Global Economy* is rife with examples of American music, Hollywood films, and media corporations like MTV overpowering local media and driving local entertainment aside, with the effect of replacing native tastes with a preference for American pop culture.³

The focus and attention on United States’ dominance in the cultural atmosphere of globalization with its crass Americanism distracts attention from other aspects or types of cultural globalization. There is, as well, a tendency to view and categorize characteristics by continents and major cultural groups without careful distinctions. Operas and ballets are associated with Europe; tango dances and reggae are viewed as Latin American; martial arts, bamboo furniture, and feng-shui arrangements are inevitably grouped as Asian. For these reasons, a powerful development emanating from Seoul, South Korea, growing rapidly and resonating throughout the Asian continent for over a decade is relatively unknown in the West. To the majority of people living outside of Asia, the mention of Korea, if there is any cognition at all, will undoubtedly bring forth images of the Korean War and news reports of events around the demilitarized zone. To the denizens of Asia, however, the “Korean Wave” will irrevocably be the most prominent association.

What then, is the Korean Wave? The term, *hanliu* (Mandarin) or Hallyu (Korean), was first coined by the Chinese media to describe what seemed like an overnight explosion of interest in Korean culture inside China.⁴ From there, the popularity of all things Korean, from pop bands to fashion, continued to grow and spread throughout the Asian continent. This development was wholly unanticipated and featured all the aspects of cultural globalization as Asian countries one after another embraced Korean pop culture. When viewed in a case-by-case analysis, especially in China and Japan, the Korean Wave has certain differences depending on the country, such as variations in the demographic categories, ef-

fective dates of origin, and reasons to explain the rise in popularity.⁵ However, one common factor is involved everywhere the Korean Wave has hit. No matter how early or how late the wave enters, or who makes up the initial base of adherents, the originating agent is always the import of South Korean television dramas. From the initial consumption of these TV serials, the effect then spills over to other cultural areas such as music, film, food, and fashion.⁶ This, then, is the established pattern of the Korean Wave.

Due to the central role of television dramas in propelling the Korean Wave abroad, it is constructive to briefly look into the content of these highly potent serials. Certain titles such as *Winter Sonata* (2002), and *Dae Jang Geum* or *Jewel in the Palace* (2003) have repeatedly made headlines or influenced major trends. *Winter Sonata* is a love story that revolves around four central characters who were classmates. Jung-sang and Yu-jin's first romance is ended as the former dies from a car accident. Dramatic events unfold ten years later as Yu-jin, who is now romantically involved with the other male classmate, Sang-hyeok, suddenly runs into her allegedly deceased first love. It is revealed that Jung-sang survived the accident, but lost his memories and has been living under another name. The plot continues to develop as old flames are rekindled and the current romances are broken. *Dae Jang Geum*, or *Jewel in the Palace*, features an entirely different theme. It is based on the story of Jang-geum, a historical figure of the Joseon Dynasty. The drama's novelty lay in the combined factor of two unique and rare themes: that of the success of a female in the historically male-dominated society, and the elements of traditional Korean food and medicine.⁷

The initial phase of the Korean Wave can be traced to South Korea's export of television dramas to mainland China, Taiwan, and several other Southeast Asian countries.⁸ The Asian Financial Crisis was shaking the economies of the continent in 1997. It is in this year that South Korean chaebols (Korean business conglomerates) and the government began reevaluating strategies to address the issues with the old economic system. The decision to export the popular culture industry received generous support from the business conglomerates that saw it as an area of potential profit. The South Korean government was also a major proponent of the strategy to draw capital from tourism and foreign investment by improving its national image.⁹ Advancements in telecommunications and hi-tech infrastructures in the meantime laid the groundwork for South Korea to efficiently develop its entertainment industry and carry out the newly adopted economic strategy.¹⁰ The government's Culture Ministry initiated its first five-year plan in 1998 to build up the domestic entertainment industry and aided South Korean colleges in opening culture industry departments.¹¹ The financial crisis affecting the other nations attributed to the attractiveness of South Korea's television dramas. Compared to Japanese and Hong Kong dramas, Korean products cost considerably less.¹² Yet, they were high in quality and Asian broadcast companies found the productions to be impressive.¹³ As mentioned by KBS official Park In-soo, "In the eyes of Chinese buyers, the quality of Korean programs are almost as good as that of Japanese soaps, especially with noticeable improvements in Korean shows over the past years. But the price is far cheaper."¹⁴

Star in My Heart, or *Wish Upon a Star*, was the first drama to enter China in 1997 when the Phoenix television network broadcast the series in Hong Kong and subsequently the mainland and Taiwan.¹⁵ The show was an instant hit and Chinese

audiences were drawn in by the modern images of “tall buildings, fancy cars, and high standard of living” projected onto their television screens.¹⁶ The popularity of this first drama resulted in a dramatic increase of Korean broadcasts, an effect enthusiastically hailed by the South Korean press. “In the past, Korean soap operas rarely got broadcast abroad... These days, soap operas starring Korean stars like Chang Dong-kun and Kim Hee-sun are among the hottest items at international TV fairs for Asian buyers,” remarked a 1999 article in the *Korean Herald*.¹⁷ At the same time, Korean pop music was making a similar breakthrough in China and Taiwan. “In particular, the boy band H.O.T. found itself topping the pop charts in China and Taiwan in 1998; the band was so popular that album sales continued to surge, even after the band’s break-up in mid-2001,” wrote Professor Doobo Shim of Singapore National University.¹⁸ In Hong Kong, South Korean stars Song Seung-hun, Song Hye-kyo, and Won Bin became household names after their drama *Autumn in My Heart* created a large following in 2000.¹⁹

By 2001, the Korean pop culture fever, *han guo re*, was sweeping through in full force and given the term “Korean Wave” by the Chinese media as “a new generation of consumers classified as the ‘Korea Tribes’ in China aggressively [adopted] and [emulated] Korean lifestyles, ranging from fashion, food and consumption patterns to even plastic surgeries.”²⁰ In many large shopping districts of Beijing such as Women’s Street, fashion stalls loudly advertising “Made in South-Korea” clothing became common features. Young Chinese students such as Ni Zhongwei and his friends often sing Korean songs at karaoke lounges, despite not understanding the language. An official at the South Korean Embassy said in a China Youth Daily interview that the interest in “Korean food, fashion, ornaments and lifestyle is gradually increasing.”²¹ Korean shows began to sideline the formerly popular Japanese programs in Taiwan. Huang Tai-yu, a social psychologist remarked, “Just a few years back, when you said you were crazy about showbiz figures from South Korea, you would be regarded as a weirdo. And now you would be criticized as being old-fashioned for not taking in the Korean craze.”²² The South Korean government, surprised and excited at the pace of events, began to draw up greater plans to support the explosive growth of Korean pop culture abroad. Korean Wave halls were planned to be set up in major cities like Shanghai, Beijing, and Hanoi, where the phenomenon had the heaviest impact. In South Korea as well, a large cultural center featuring exhibitions from all aspects of Korean pop culture was planned to be built near the capital’s famed Dongdaemun (East Gate) to attract tourists and fans. A new “Korean Wave policy planning team” was created to be in charge of these large-scale projects.²³

In 2002, the government created the Korea Culture and Content Agency to assist in the promotion of the country’s cultural exports.²⁴ South Korean shows leaking into North Korea influenced its women into copying the hairstyles of popular South Korean actresses, an act the North Korean regime subsequently cracked down upon. The surprising defection of a North Korean soldier who crossed the demilitarized zone stated that his action was spurred by what he saw from South Korean programs.²⁵ Hong Kong tabloids began to cover South Korean celebrities and local vendors such as Dicky Tsang reported boosts of sales of Korean music and videos. Zhang Jianhua, a Beijing shop owner, expressed that “In the 80s it was Japanese, Taiwanese and Hong Kong singers and movies, but now Korean is the thing.”²⁶ The popularity of Korean actor Jang Dong-gun and actress Kim Nam-ju

in Vietnam was potent enough to convince the South Korean government to invite them to an official dinner held for the visiting Vietnamese president, Tran Duc Luong. South Korean programs proved so popular that the Vietnamese population “sometimes had to choose between two aired at the same time on Hanoi’s total of four channels.” South Korean fashion also began emerging in the dress styles of trendy youngsters in Vietnam’s major cities.²⁷ 2003 saw the Korean Wave penetrate the Philippines, where the airing of “*Autumn Story*” started the “Koreanovela” craze. Korean shows that followed surpassed the dominance of local soap operas and the country’s largest TV networks competed intensively for the rights to the latest Korean serials.²⁸

2005 was an important year for Hallyu, and commonly viewed by many as the peak of the phenomenon, especially in the regions first hit by the Wave. In the subways of Taiwan’s capital, the television drama *Dae Jang Geum* (*Jewel in the Palace*) was used to advertise South Korea itself.²⁹ Hong Kong shopping centers and restaurants saw rare and unprecedented declines in business as *Dae Jang Geum* pulled the local population back to their homes during the hours that show was airing on local channels. The show “became the most-viewed TV series in Hong Kong television history” as it pulled in nearly three million viewers.³⁰ An internet poll conducted by the major Chinese internet news website Sina.com showed that 81 percent of Chinese internet users liked Korean dramas, and 50.2 percent favored Korean productions, far ahead of the 21.7 percent that preferred domestic productions.³¹ Headlines were made when Chinese president and General Secretary of the Communist Party of China, Hu Jintao, told visiting South Korean dignitaries that “It’s a pity that I cannot watch ‘*Dae Jang Geum*’ everyday because I am so busy.” Other top officials such as Vice President Zeng Qinghong and Chairman of the Standing Committee of the National People’s Congress, Wu Bangguo, who also revealed their penchant for the show created a burst of Chinese media coverage on the domestic popularity of Korean culture.³² It was in 2005 as well that the Korean Wave’s effects began to be noticed far from the Asian continent. South Korean shows gathered large fan bases in the Middle East. The Korean Broadcasting System receives thousands of fan letters from the region. More than 300 Egyptian fans set up an internet fan club and website dedicated to the same series responsible for the Hallyu craze in Japan, *Winter Sonata*. An undergraduate at Cairo’s Ain Shams University expressed her desire to “marry Bae Yong Joon and convert him to Islam,” as she pleaded with South Korean reporters for the actor’s telephone number.³³

In 2006, Uzbekistan saw the Korean Wave in action as *Winter Sonata* was aired repeatedly on its national broadcasting station and the airing of *Dae Jang Geum* emptied the streets in the evening, much like the occurrence in Hong Kong. The popularity of Korean dramas compelled the Uzbek Foreign Ministry to request the Korean Embassy to invite Bae Yong Joon and Choi Ji-woo, the main stars of *Winter Sonata*, for a state visit.³⁴ By now, the amount of South Korean programs airing on government TV networks in China was greater than all other foreign shows combined. South Korean president Roh Moo Hyun’s visit to Mexico even saw flocks of local fans carrying placards of their favorite Korean stars gathered outside his hotel.³⁵ In 2007, Korean pop singer Bi Rain held a concert in Ho Chi Minh City, Vietnam’s most extravagant stage performance to date, and one that sold out in record time, despite ticket prices costing nearly half of what most city

residents made in a month.³⁷ Iran also witnessed a surge of interest in Korean dramas after *Dae Jang Geum* was aired in 2007. Since then, the demand for Korean shows has resulted in three of Iran's seven channels airing Korean programs, and many people even use music from these shows as their cellular phone ringtones.³⁷ In Mongolia, the content of Korean dramas and Korean songs are frequent topics of daily conversations. Popular series such as *Dae Jang Geum* are aired repeatedly during prime time. Songs by popular Korean artists and groups such as Rain and Shinhwa top the Mongolian music charts. Most young children have stationary and accessories featuring Korean celebrities.³⁸

In 2009, Johan Jaaffar, a Malaysian journalist, wrote a column for the *New Straits Times* sharing observations of his own daughter as one of the typical followers of the now mainstream Korean Wave. He talked of her habits: hardly watching Hollywood films or listening to English music, but knowledgeable of all the latest Korean dramas and pop groups. Jaaffar also described his amazement at young girls and boys watching Korean game shows, despite not understanding the Korean language. In Malaysia, Korean *manhwa* (comics) also edged out formerly popular Japanese mangas amongst its youth audience.³⁹ In Singapore, fans such as Nurul Ain Samsuri jumped at the chance to purchase the fast selling tickets for the 2009 Seoul'd Out Concert featuring several popular Korean pop groups. She states while on her way to the airport, "Hallyu is taking over Singapore."⁴⁰

This chronological view of the Korean Wave unfolding and spreading across Asia and further offers an idea of the magnitude and rapid pace of the events. In only two decades, South Korean pop culture has taken pole position above the cultures of former influential powers such as Japan and Hong Kong. In Asia, Korean culture now dictates major trends in a variety of aspects ranging from fashion to tourism. This explosive growth of Hallyu and unanticipated South Korean cultural dominance can be explained by taking an in-depth look at the various regions it affected.

In China, the Korean Wave took off based on a variety of reasons. First and foremost, there is an important cultural connection between the two countries. China and Korea have shared a history of cultural interaction for thousands of years, although it was predominantly that of the Han Chinese influencing Korea's culture - everything from language, to social structures, to customs and values. Confucian traditions and these cultural similarities are instantly familiar to Chinese viewers, a factor acknowledged by members of Korea's media enterprises. As KBS official Park In-soo states, "Chinese viewers don't feel resistance to Korean shows because the two countries share the same cultural background."⁴²

An equally important factor was the social context of China itself in the late 1990s when South Korean dramas hit the mainland. A temporary lack in traditional culture created an opportune setting as Korean dramas began to flow in.⁴³ Memories of the chaotic Cultural Revolution were still relatively fresh in the hearts of the Chinese population. Following a planned economic system during Mao's reign kept the country impoverished. Deng Xiaoping's "Reform and Opening" policy of 1978 aimed at addressing these issues drastically changed the economic landscape and resulted in great success, modernizing China at a rapid pace. In the flurry of these tremendous transformations and the decades spent following the Communist ideology of destroying old traditions, China's rich cultural history seemed to have been completely forgotten in its scramble for a new society.

For example, the highly popular drama *Dae Jang Geum* (*Jewel in the Palace*) directly appealed to the Chinese based on the shared historical connection. Known as *Da Changjin* in China, the Korean series was about a woman who rose from humble origins to be the palace physician during the Joseon Dynasty. The setting and plots were very familiar to the Chinese audience because they were “almost identical to China’s Ming Dynasty.”⁴⁴

Yet beyond the historical dramas, the familiar cultural values evident in shows of contemporary settings greatly contributed to Hallyu’s success. Nearly all Korean shows such as the first one to gain widespread popularity, *Star in My Heart*, incorporated traditional elements despite their central plots revolving around romance and heartbreak. As such, these imported dramas instantly struck a chord with China’s viewers living in the rapidly modernizing society void of traditional values. “The Chinese culture and the Korean culture overlap in many ways, so Chinese audiences can easily identify with the characters and their behaviors. We see a purer form of Confucianism and are refreshed by it because we feel a sense of belonging,” explained Jiao Yan, a researcher with the Chinese Academy of Social Sciences. “The Confucius tradition reflected in these Korean dramas and books are like *déjà vu* to us because we cannot find it in our own writers and artists,” stated Wang Li, a Beijing publisher with the Chinese rights to several South Korean best-sellers.⁴⁵ These dramas, with scenes of “families huddling around dinner tables,”⁴⁶ were full of familiar Confucian-based values such as filial piety and family relations; some even felt that the “Koreans [were] more like the Chinese than the Chinese themselves.”⁴⁷ The success of Korean dramas benefitted heavily from a longing and nostalgia for values taught to the Chinese as children and other merits from a “more innocent China that [was] vanishing amid the wealth and materialism.”⁴⁸

There was also a more contemporary and individualistic appeal to Korean dramas, that of modernity, the very aspect that the Chinese reforms and social transformations were aimed at. Young Chinese viewers “fascinated by the ‘sophisticated and urban lifestyles’” presented by Korean productions focused their attention on the fashion, hairstyles, and modern images of fancy cars, tall buildings, and luxurious lifestyles.⁴⁹ Such images of a modernized Asian country provided a model of a prosperous future that the Chinese, through the rapid developments in their own economy, might be able to attain.⁵⁰ As Chong Zi writes in an article for *China Daily*, “I can find bits and pieces of myself and friends within a Korean mini-series whose characters are obsessed with money and social status, and are often depressingly unable to be direct about their true feelings.”⁵¹ Tsinghua University student Qu Yuan shares her opinion, “We feel that we can see a modern lifestyle in those shows... We feel that we can live like them in a few years.”⁵²

A slight political component was involved as well in helping boost Korean pop culture, as there was still a noticeable anti-Japanese sentiment lingering in many Asian countries that suffered from Japanese occupation, especially China.⁵³ As Ms. Jin, who studied both Korean and Japanese languages, explains, “There is no obstacle to our accepting South Korean culture, unlike Japanese culture. Because of the history between China and Japan, if a young person here likes Japanese culture, the parents will get angry.”⁵⁴

Korean dramas were also highly suitable for viewers of all ages with their clean language and stories, and also the fact that there is “generally barely a whiff of sex despite the sometimes turbulent love triangles that emerge.”⁵⁵ As veterans

of the Korean industry note, modernizing countries ready to accept Western values still find elements of Japanese and American mass cultures “irrelevant to their reality.”⁵⁶ Chinese opinions shed insight into their discomfort with these elements. Huo Kan of Tsinghua University voiced the view that “American dramas are too modern... Something like ‘Sex and the City’ is too alien to us.” Beijing University graduate student Jin Yaxi states, “We like American culture, but we can’t accept it directly.”⁵⁷ The Beijing publisher Wang Li agrees, “...a whole family of several generations can enjoy a show together as it is devoid of sex and violence.”⁵⁸

Thus, Korean dramas appealed to the Chinese based on multiple factors: political, historical, cultural, and social. Negative sentiments remaining in the hearts of the Chinese from the brutal occupation by Japan in WWII allowed South Korean pop cultural elements to surpass previously established Japanese influences with relative ease. As well, in contrast with the violence and sex frequently featured in American media, along with the “highbrow” content of European productions, Korean sitcoms presented content that did not generate discomfort with any demographic.⁵⁹ The presented historical themes “[awakened] the distant memory of their own traditional civilization” and generated feelings of pride in their rich, influential culture.⁶⁰ Emphasis on deeply rooted Confucian values brought forth nostalgia and reminded the Chinese of things lost in the recent decades of extreme changes in all directions.⁶¹ Images of a modernized nation, economic prosperity, and luxurious lifestyles invoked attainable fantasies in the minds of the Chinese.⁶² As the Korean Wave’s first splashes hit the shores of China, viewed as having “failed to balance traditional culture and modern Western thought,”⁶³ the country’s longstanding historical dominance in cultural influence reversed course as the population looked with aspire towards Korea. Lui Mei, a Chinese resident in Seoul expresses this sentiment, “Korean pop culture skillfully blends Western and Asian values to create its own, and the country itself is viewed as a prominent model to follow, both culturally and economically.”⁶⁴

The Korean Wave in Japan took a different shape. Whereas in China, the immediate effects encompassed a wide range of the population, the developments in Japan were centered on one main demographic. Hallyu in Japan also entered a few years behind China and the other Southeast Asian countries. The origins can as well be narrowed to one single title, and effectively to one single actor. The 2002 drama, *Winter Sonata* is credited with triggering the sensational response in Japan and is still recognized as a central element to the Japanese version of the Korean Wave.⁶⁵ As the drama was first broadcast in 2002, middle-aged Japanese women including those in the age range of 40 to 60 quickly became enamored by the main actor, Bae Yong-joon.⁶⁶ They were mesmerized by his handsome looks, muscular body, and the characteristic of fiercely loyal love that he displayed on screen - all features that are regarded as rare in Japanese men.⁶⁷ His character’s undying love that survived ten years of car accidents and amnesia struck a chord with the middle-aged housewives who were reminiscent of their youthful romances and longing for affection.⁶⁸ As a result, Bae Yong-joon single-handedly created the “Winter Sonata syndrome” and its massive, loyal fan base.⁶⁹ Now known by the honorific title “Yonsama”, he became Korea’s first sex symbol⁷⁰ and established the archetype for Korean males in Japan – romantic and sensitive, with strapping bodies.⁷¹

Despite this narrow spectrum of followers, Hallyu’s effects were being felt in Japan. As a result of Bae’s and *Winter Sonata*’s success, Japan became the largest

market for Korean actors, where almost every major male actor has an “official store” in his name.⁷² Bars with names like “Seoul Man” even began popping up in Tokyo’s largest gay district of Shinjuku *Ni-chōme*.⁷³ Bae Yong-joon’s personal fame earned him television appearances with Japanese prime ministers⁷⁴ and becoming a spokesman for Japanese electronics giant Sony.⁷⁵ A Japanese ambassador revealed in a press conference in Seoul of a confession that a Japanese businessman made to him, who lamented on his lonely marriage as his wife abandoned him to watch *Winter Sonata* every night it aired.⁷⁶ Maki Tsuchida, a journalist who has watched the Korean Wave unfold in Japan reported a distinctive trend of the female population. Women in their 40s and 50s, who were previously considered inactive internet users because they were preoccupied with household duties, became avid bloggers and users of the World Wide Web to find information on events relating to their favorite Korean idols.⁷⁷ A crowd of housewives swarming Japanese airports to welcome a South Korean actor is not an uncommon scene.⁷⁸

Due to the irresistible appeal of Korean males as portrayed by the successful dramas, Japanese-Korean matchmaking services such as Rakuen Korea, which had roughly 6,400 clients by 2005, began to emerge in Japan to capitalize on the “Winter Sonata syndrome.” Kazumi Yoshimura, one of the company’s clients who already flew to Seoul 10 times in two years shared her opinion as she was on her way to another blind date with a Korean man, “South Koreans are so sweet and romantic – not at all like Japanese guys, who never say ‘I love you.’”⁷⁹

After the initial Korean pop culture foothold established by television dramas led to a growth of interest in other cultural areas, Korean pop music began to make its own accomplishments and attract a fan base comprised of the younger Japanese generation in their 20s and 30s.⁸⁰ As early as 2002, Japan’s leading record label, Avex, began signing distribution deals with South Korean pop artists and groups,⁸¹ a practice that has continued to present day with current popular groups regularly making debuts in Japan.⁸² For example, the Korean boy band TVXQ has established a record by becoming the “foreign artist with most number-one singles” on Japan’s Oricon music chart with seven number-one singles since their debut in 2006.⁸³

As the Korean Wave penetrated the other countries of Asia and beyond, the developments were also varied but had visible effects. The way it originated never strayed from the set pattern of imported dramas being the first medium to attract a fan base that expanded their interests into other areas of Korean culture. Singaporean fan Loh Choon Fei recounts that her love for all things Korean “all started with dramas. I like to ask teachers about the things I watch on TV.”⁸⁴ In the Philippines, identical to China, Korean dramas were first imported for their inexpensive price, where “buying the rights to a Korean drama was cheaper than producing local dramas.⁸⁵ As the first drama, *Autumn Story*, was broadcast in the Philippines, the “Koreanovela” phenomenon was born, and those hooked on the dramas advanced their interests to Korea’s culture, food, and culture. Korean language classes increased in demand as fans began to sing along to Korean pop songs in local KTVs (karaoke lounges).⁸⁶ The progression was identical in Vietnam, as broadcasters chose dramas like *Autumn Fairy Tale*, *Jewel in the Palace*, and *Winter Sonata* for their high qualities and cheap prices.⁸⁷ The exposure and growth of their popularity similarly induced a taste for more Korean related elements. “After I saw ‘*Autumn Fairy Tale*,’ I decided to learn all I could about Korea – the food, the

culture, the history....I've been 'obsessed' with it since!" recounts Nguyen My Ha, who studied Korean language for four years at his university and hopes to land a job in Seoul when he graduates.⁸⁸

The preference for Korean pop culture in these other nations generally went in accordance with the variety of the reasons for its popularity in China and Japan. Historical and political issues were a factor, relevant to many of the South-east Asian countries that experienced Japanese occupation similar to China.⁸⁹ In the case of Vietnam, its own rocky history with China made K-pop more welcoming than Chinese pop.⁹⁰

The aesthetic appeal of Korean actors enjoyed by the Japanese was similarly shared by fans in Indonesia, also comprised of mostly women. Hallyu in Indonesia started with the broadcast of *Winter Sonata* as well.⁹¹ Cecilia Ros, a female fan states, "If we are asked what we like about Korean dramas, most of us would say the boys." Another fan, Cinthia, concurs, "All the boys are handsome. Korean faces are delicious."⁹² Likewise, Vietnamese fans such as Khat Lan Phuong and Hoang Kim Thanh share this opinion, "The men were so handsome, the women so beautiful and their skin and make up was always so perfect."⁹³

The novelty of Korean pop culture and the alternative that it offered prevailed over the already well-known American and Japanese pop cultural elements that were previously dominant.⁹⁴ Indonesian movie buff, Shanne, expressed the view that she was "bored with Hollywood movies."⁹⁵ Nina in the Philippines was "attracted to K-pop because it was different from the rock scene in the United States and the Philippines." Other Filipinos were also tired of the generic local soap operas that ran for years.⁹⁶ Lia, a fan of Korean music from Indonesia, commented on her boredom of music from the West and Indonesia; Korean pop music satisfied her need for "something different."⁹⁷

Shared cultural similarities and values were dominant themes as well. Celcilia Ros preferred Korean movies and dramas because she found that "From the way they talk, to their food, they are close to Indonesia culture."⁹⁸ The balance of tradition and modernity was an aspect that also struck a chord with Vietnamese viewers.⁹⁹ In the Philippines, what viewers saw in the Korean shows did not differ greatly from Filipino values of "love for family, the importance of respecting elders, and fighting for one's true love."¹⁰⁰ This high regard for traditional values was especially important as the Korean Wave penetrated non-Asian regions in the Middle East. Mohammad Fazaeli, an Iranian journalist, explained television's role as a family entertainment, and the content of Korean dramas was much more suitable than western productions often featuring violence and sexuality.¹⁰¹ Alireza Abazari is inclined toward Korean dramas due to their "approach toward traditions in the modern day" and the way they "pay attention to socio-humanitarian values."¹⁰² KBS Radio Korea International producer Bae Jung Ok agrees that the Korean shows, featuring little violence and sex, focusing instead on family issues, love, and filial piety fit the conservative values of the Islamic regions.¹⁰³

While Hallyu has dramatically influenced the regions it has penetrated, its effect on the origin nation of South Korea has been just as monumental. The explosive growth in popularity came to be just as much of a shock to the South Koreans themselves. In the early 1990s, no one would have suspected a sudden influx of Korean culture in Asia, where it was far below the recognition and status of Chinese, Japanese, and even Taiwanese cultures.¹⁰⁴ Older generation Koreans

grew up under the influences of Hollywood and the songs of the American Billboard charts.¹⁰⁵ The shift can be seen in the statistics. In Taiwan, where Gala TV paid \$1,000 for an hour of a Korean show compared to up to \$20,000 for a Japanese show in 2000, paid from \$7,000 to \$15,000 for a Korean drama versus that of \$6,000 to \$12,000 for a Japanese drama in 2005.¹⁰⁶ In fact, the substantial rise in the cost of Korean dramas, up to nearly \$20,000 per episode, made them unaffordable for some TV stations, indirectly contributing to a reduction of their airtime.¹⁰⁷ The size of the South Korean entertainment industry itself grew rapidly from \$8.5 billion in 1999 to \$43.5 billion in 2003, a growth of over five times in a four year time span.¹⁰⁸

Korean male celebrities reaped the benefits, now among the highest-paid actors in the world outside of Hollywood. Jang Dong Gun, who became one of the highest-paid actors in Asia as a result of the Hallyu phenomenon, expressed his own surprise in an interview, stating that it was “still a little hard to believe that it’s gone this far.”¹⁰⁹ Bae Yong Jun, responsible for the “Winter Sonata Syndrome” in Japan, has an estimated worth of \$100 million and charges \$5 million per film, the highest in Asia.¹¹⁰ Across the continent, many Korean actors became household names, such as Ahn Jae Wook, who bested Leonardo DiCaprio in popularity in a Chinese poll.¹¹¹ Some South Korean actors and actresses have even become more popular in other countries than at home.¹¹²

One of the most visible effects has been its role in improving the national image of South Korea. Prior to the birth of the Korean Wave, the Korean peninsula was often associated with the gloomy image of military regimes and division.¹¹³ Now, cutting-edge technology and trendy entertainers are more likely to be the common association. The transformation in image can be seen in the attitudes of Asians such as Candy Hsieh from Taiwan, who stated that her old image of Korea as a “feudalistic, male-centered society” changed to that of “an open society, democratic.”¹¹⁴ A survey in 2005 conducted by the Korea Trade center showed that South Korea’s overall image in Japan and China had considerable improvements, with similar results in other Asian countries such as Taiwan and Thailand.¹¹⁵ Jin Chang-soo, a senior fellow of South Korea’s think tank, the Sejong Institute, notes the improvement of image in Japan, stating that “Japanese people came to have a better understanding of Koreans after they watched Korean dramas.”¹¹⁶

An effect experts such as Kim Hyu-jong of Chugye University of Arts earlier predicted came to be true; the heightened national image brought substantial economic benefits for South Korea.¹¹⁷ Improved national image as a result of Korean dramas’ overseas effects has helped to contribute to the association of Korean goods as quality products, much different from a decade earlier. Restaurant owner Ohn Dae Sung shares the opinion that “If a Japanese television set stopped working, the Chinese would say something’s wrong with the power lines. If a South Korean television set stopped working, they’d say it was the fault of the set.” In complete contrast, South Korean technologies are now coveted products in vogue throughout Asia.¹¹⁸ Lai Tsung Pi, the vice president of Gala TV in Taiwan, shared his view that the increase in willingness for Taiwanese people to buy Korean products was a result of Korean dramas, referring to the sharp rise in sales of South Korean consumer goods in a five year time span.¹¹⁹ Jim Sohn, chief executive of LG Electronics in China has stated that he is “sure there is a connection” between improvements in sales and the Korean Wave. Korean automobile manufacturer

Hyundai became “No. 2 in sales among automakers in China,” despite a late entry, and its Chinese division president, Um Kwang Heum, also noted of benefitting from the Korean Wave.¹²⁰ Korean fashion shops are now part of Vietnam’s high-end malls such as the Diamond Plaza in Ho Chi Minh City, with their names domestically considered as luxury brands.¹²¹ Even as far as the Middle East, counterfeit products such as satellite receivers with Chinese origins bear “Made in Korea” labels, hoping to catch more sales with the fake stamp.¹²²

Korean star power also visibly benefitted Korean products being sold across the continent. Daewoo Electronics, who hired actor Jang Dong Gun in 2001 as its Vietnam spokesperson, saw an increase in its refrigerators’ market share from a nominal number to 34 percent.¹²³ Samsung Electronics saw skyrocketing sales numbers of their cellular phones and computer monitors as a result of advertisement campaigns featuring popular actor Ahn Jae-wook.¹²⁴ In Vietnam, the South Korean company LG Household & Health Care dominated the cosmetics market, rising above international leaders such as Lancome, Shiseido, and Revlon after it hired actress Kim Nam-ju as their model.¹²⁵ Bae Yong Joon has helped to establish the Korean cosmetics company, The Face Shop, as a major competitor in Singapore, by becoming the brand’s model. The company went from a single outlet in 2005 to nineteen by 2009.¹²⁶

Korean cuisine has also shared a marked increase in popularity. Long overshadowed and caught between the popular cuisines of China and Japan, Korean cooking has emerged from its small niche as a major pillar of Asian cuisine in recent years due to Hallyu’s effect. Yasushi Hatta, a Japanese freelance journalist and food columnist noted the trend of Korean restaurants “[popping] up here and there” in Japan since 2005 as a result of the Korean Wave.¹²⁷ The same pattern was observed in Vietnam, where numerous Korean restaurants specializing in Korean BBQ, noodles, seafood, and rice dishes sprouted up in its major metropolitan areas such as Hanoi and Ho Chi Minh City.¹²⁸ The interest in Korean cuisine peaked in many regions as a result of the drama, *Dae Jang Geum* (*Jewel in the Palace*), that featured detailed displays of extravagant imperial banquets and Korean cooking. Certain tourism packages offered by Hong Kong travel agencies that took tourists to the filming site of *Dae Jang Geum*, which included the “tasting of ‘authentic’ Korean cuisine” shown in the drama, remained fully booked long after the show was aired on Hong Kong’s TVB Jade channel.¹²⁹ A Korean restaurant in Hong Kong even began to offer its own nine-course imperial banquet as part of the menu, resulting in long queues of interested customers waiting outside its doors.¹³⁰ A Beijing newspaper reported a 30 percent rise in the business at some Korean restaurants in 2005 due to *Dae Jang Geum*’s popularity. A Korean businessman in Beijing who capitalized on the trend by registering his restaurant under the same name as the television show reaped the benefits as his business expanded into a chain of nine restaurants in the Chinese capital, noting that “Korean pop culture has certainly helped with my business.”¹³¹

The movement of people across the Asian continent has also shifted dramatically in South Korea’s favor, which has not traditionally been a popular tourist attraction in Asia. From 2003 to 2004 alone, the number of foreign tourists going to South Korea increased from 2.8 million to 3.7 million.¹³² South Korea’s booming tourism industry can effectively be attributed to the success of Korean dramas abroad. Many production companies began setting up filming locations of popular

dramas as parts of packaged tours where “housewives as far away as Honolulu came on group tours to visit sites filmed in their favorite Korean soap operas.”¹³³ The New Fantasy Travel Agency in Taiwan showed that 80 percent of the total travelers going to South Korea pick the television tours to visit the filming sites.¹³⁴ As previously stated, tours featuring Korean cuisine also attracted growing numbers of tourists. Customers can even book packages that specifically focus on the Korean dish of kimchi, where they visit a museum dedicated to the dish and its production process.¹³⁵ Filipino fans such as Kelly explained that her motivation for going on a “Koreanovela” tour with her friends, where they visited the locations of several popular dramas, was due to the *Spring Waltz* drama, stating that “the sceneries were so lovely that I dreamt of visiting the place.”¹³⁶ South Korea became a “top holiday destination” for Singaporeans. Sharon Foo of Dynasty Travel in Singapore, a company that also offers television drama themed tours, stated that they receive “inquiries for the year-end packages as early as May” and sell out every year.¹³⁷ Bae Yong Joon’s wildly popular drama continued to exert its influence, where the filming locations of *Winter Sonata* have become “must-go destinations” for fans.¹³⁸ According to Andrew Salmon of *The Korea Times*, “‘*Winter Sonata*’ did more for Korea’s image in Japan than any PR activity by the Korean Tourism Authority could ever hope to match,” referring to the frenzy of Japanese tourists visiting South Korea as an effect of Bae’s “Winter Sonata syndrome” to go on “Yonsama shopping tours.”¹³⁹ Indonesian fan Lanny Tricya, one such participant of a shopping tour, responded in an interview that she “rewatched Bae Yong-joon’s *Winter Sonata*, memorizing all the beautiful scenes,” and bought “five woolen shawls, a neutral-colored sweater, and an overcoat in a boutique.”¹⁴⁰ Between 2003 and 2004, tourism numbers showed that Japanese visitors to South Korea grew by 40 percent. Bae Yong Joon’s personal residence in Choonchun received 400,000 tourists in 2004, an increase of 165 percent compared to 2003. The “Winter Sonata syndrome” was estimated to have brought South Korea roughly \$1 billion in tourist revenue in 2005.¹⁴¹

South Korea has also become a significant center for overseas education. Official statistics in 2010 showed that Chinese students studying in South Korea increased 10-fold in a six year time span and made up 70 percent of South Korea’s entire international student population, an unprecedented situation and one sharply contrasting to the long historical trend of China being the cultural center for Korean students. Chinese students revealed that their decision to study in South Korea stemmed from what they saw of the country through Korean television, which convinced both them and their parents that the modern and developed nation was an ideal place for study abroad.¹⁴² South Korea has also become the biggest destination for Mongolian students seeking overseas education, where 1.2 percent of the total Mongolian population currently resides. In Mongolian schools, Korean is second only to English as the preferred choice of foreign language study, “far ahead of Russian, Chinese, or Japanese.”¹⁴³ The increased interest in Korean language studies can also be seen in Singapore, where non-degree courses offered to the public by the National University of Singapore quickly multiplied from two classes to sixty between 2003 and 2009.¹⁴⁴ In the South Korean capital of Seoul, Chung-Ang University has even set up both graduate and doctorate degree programs in the study of the Korean Wave itself.¹⁴⁵

Indeed, Korean dramas significantly changed Asia’s cultural landscape. Its pop cultural influence greatly enhanced South Korea’s image and anything

originating from this new cultural center of Asia. Korean businessmen in Taiwan have received huge profits by marketing drama-themed photos, books, CDs, and stationary products.¹⁴⁶ K. Kesavapany of Singapore's Institute of South East Asian Studies notes that "Young people delight in Korean movies, fashions, pop stars, foods and Korea-made products such as cars and mobile phones."¹⁴⁷ In China, even the stigma of plastic surgery has visibly lessened. The number of young Chinese visiting cosmetic surgeons, hoping to look more like the beautiful Korean stars they have seen on television after the operation, has visibly increased in the recent decade.¹⁴⁸ The characterization of Seoul as the "'cultural Mecca' of China's Y Generation", replacing that of the West has become a common expression for many.¹⁴⁹

With the dramatic success of Korean pop culture spreading throughout Asia, its rapid growth has become characterized by some as more of an unrelenting assault rather than peaceful cultural exchange. Over the years, the phenomenon has drawn resistance from parts of the local population as well as concern from local governments. As early as 2001, a state-controlled newspaper in Vietnam listed the dominance of South Korean programs as one of the "10 most embarrassing cultural events" of the year.¹⁵⁰ It is interesting to note that this backlash harkens to the examples made by Barnet and Cavanagh in their essay, "Homogenization of Global Culture."¹⁵¹ The exception is that antagonism is directed against South Korea rather than the United States. The similarities, however, are striking; for instance, the imported media's dominance over local productions is the case in the Philippines. Buying the rights to Korean dramas was considerably cheaper than the capital needed to produce local shows. An executive of a Filipino broadcasting company revealed the fact that showing an imported drama only required one fourth the capital of a local production, generating more revenue with less investment.¹⁵²

The characterization of "cultural invasion" has been a large component of the backlash against Korean cultural exports.¹⁵³ A very outspoken protestor against South Korean influences has been one of China's most prominent and successful actors, Zhang Guoli. He has gone as far as to label Chinese stations broadcasting Korean dramas as "selling out the nation," and has urged citizens to buy Chinese goods instead.¹⁵⁴ Zhang has expressed the feeling that Chinese media has been overly critical and unfavorable toward mainland productions, and that if the very same plots and pacing found in Korean shows were produced by China instead, "it would have been thrown to the dogs." Like Zhang, Hong Kong's own world-renowned celebrity, Jackie Chan, has shared the view of media bias in favor of South Korean productions. He has complained of the Hong Kong press giving too much coverage to South Korea, giving an example that a visiting Korean star might receive as much as four pages from newspapers while local artists received minimal coverage.¹⁵⁵ In Japan, complaints of "cultural imperialism" have been surfacing across blogs and *mangas* (Japanese print cartoons).¹⁵⁶ Xenophobia has characterized the Japanese counter-wave against the Korean Wave. A Japanese comic titled "Hateful Hallyu," critical of not only the Korean Wave but Korean culture and history as well, reached the top of the Japanese Amazon website's reservation list in 2005. On the internet, there is also a prominent "I Hate Korean Wave" campaign.¹⁵⁷

As the Hallyu effect peaked in the mid-2000s, local governments and media began to take certain measures in response to their concerns about the in-

creasing Korean influence on both culture and local productions. The Taiwanese government considered a 20 percent tariff on Korean programs.¹⁵⁸ Japanese broadcasters reduced and removed special airtimes designated for Korean programs, justifying their actions by claiming that such shows were “no longer commercially viable,” despite the growing popularity of Korean culture.¹⁵⁹ The Chinese government’s concern over Korean products’ sidelining domestic production has led its State Administration for Radio Film and Television (SARFT) to reduce dramatically the airtime of Korean dramas on national television. Statistics produced in 2004 showed that of 12,000 drama episodes produced by mainland China, there was only airtime for 5,000 episodes, resulting in a financial loss of roughly 3 billion RMB (\$427 million).¹⁶⁰ As such, the SARFT called for a stricter screening process and limiting Korean drama airtime in December 2005.¹⁶¹ The administration took action in 2006 after its initial announcement by reducing the amount of airtime of all foreign programs by 50 percent: Korean dramas consisted of the largest portion.¹⁶² In 2007, SARFT targeted specific Korean dramas and blacklisted several titles due to their “[smearing of] Chinese history.”¹⁶³ Yet, despite the backlash and growing challenges in recent years, the Korean Wave still continued its unabated expansion and exerted its influence in the affected regions.

The current situation of the Korean Wave is not as straightforward as in the early 2000s, when its spread and rapid popularization was unquestionably on the rise. The potent influence of Korean pop culture was enough to draw considerable protest in some countries, compelling even the local governments to take action. Many observers both outside and within South Korea have noticed that Hallyu appeared to be gradually waning. It is no longer inducing the near feverish following as it did a few years ago.¹⁶⁴ However, the protectionist policies enacted by the local governments, such as those from China’s SARFT, do not seem to be directly responsible for the slowing down of the Korean Wave. Younghoon David Kim, a Korean executive who visited China in 2007, reported that, despite government regulations making Korean dramas only available after 10pm, families continued to gather together late at night to view these shows.¹⁶⁵

Yet, South Korean businesses and government officials are indeed concerned about the future of Hallyu. The recent years have seen a flurry of activity and brainstorming on their part to devise new ways to sustain and propel the Korean Wave, such as the special Hallyu forum that was organized by the Korean Foundation for International Culture Exchange (KOFICE) in collaboration with the Federation of Korean Industries (FKI), it was attended by a wide array of entertainment industry professionals, business leaders, think tank experts and government officials.¹⁶⁶ Financial experts such as Martin Roll are advising major Korean companies such as Samsung and LG to avoid becoming complacent, stating that these brands “have been helped greatly by Hallyu....but will play less of a role in brand building in the future. Hallyu is still important but it will slow down.”¹⁶⁷ Some South Koreans have suggested changing the characteristic of the Korean Wave to find new channels for growth. A recent editorial in the *Korea Herald* suggested that with financial gains from the Korean Wave in decline, “a move away from purely economic concerns may be what is needed to revive and sustain Hallyu,” also calling the overemphasis on government support for promoting Hallyu a mistake.¹⁶⁸ South Korea’s Culture Ministry initiated a large-scale five-year “Han Style project” in 2007, responding to Culture Minister Kim Myung-gon’s calling

for the need to “create new Hallyu.” The Han Style project deviates from the pop culture spectrum of the Korean Wave. Its \$289 million investment instead focuses on “six traditional cultural themes - Hangeul (Korean language), hansik (Korean food), hanji (mulberry paper), hanbok (traditional dress), hanok (traditional house) and hankuk eumak (traditional music).” Kim stated at a news conference, “We have so far failed to redefine the value of Korean culture,” and also stated that the Korean government will “fully support the globalization of Korean culture” with the “Han Brand.”¹⁶⁹

Entertainment industry executives such as Park Chang-sik reported disappointing figures at the recent forum held by KOFICE and FKI, stating that “Seven out of ten dramas that we have produced failed to get the revenue that we aimed for.”¹⁷⁰ However, many find the Korean entertainment industry itself to be at fault for the waning effect of the Korean Wave. Benny Lau, one of the first in Hong Kong media to take notice of Korean pop culture, reported that “Indeed the Korean Wave in Hong Kong has died down in the recent couple of years.” He suggests that the “core of the Korean force lies in its TV dramas.”¹⁷¹ This is a reasonable argument, given the central role of Korean dramas in initiating Hallyu in every region it entered. Korean columnists have called for the improvement of Hallyu products, arguing that Korean dramas of recent years that “have relied on tried-and-true formulas” have failed to attract followers.¹⁷² Hwang In-hak, deputy secretary general of KFI, has urged the entertainment industry to “generate creative stories with solid storylines to meet the rising expectations of viewers overseas.”¹⁷³ Winnie Tsang of Hong Kong’s Golden Scene film distribution company has also pointed to the lack of new Korean dramas becoming major hits, as well as noting that established celebrities such as Bae Yong Joon have not been producing much in recent years.¹⁷⁴ Even in Mongolia, where the Korean Wave is still going strong, Korean ambassador Park Jin-ho reports that “Mongolians are now a little bit fed-up with the monotonous plots and similar storylines of Korean dramas.” He also called for the Korean television industry to devise more creative content in order to continue the growth of the Korean Wave.¹⁷⁵

Hallyu’s effects are certainly not as prominent and overpowering as they were in the peak period of 2005. Some scholars such as Anthony Fung, associate professor of the Chinese University of Hong Kong’s School of Journalism and Communication, suggest that the decrease in visibility is only a result of less media coverage due to its mainstream familiarity, lacking the sought after aspect of novelty. He reports that “In fact, Korean idols are still popular among young people in Hong Kong... There is less exposure, but it does not mean Hong Kong people are sick of Korean pop culture.”¹⁷⁶ In this sense, Korean pop culture has simply become a customary feature of daily life. Hallyu is, as well, still reaching out further, past the non-Asian regions. In the United States, Korean dramas are regularly aired on the ethnic channels of major metropolitan areas in such locations as Los Angeles and New York.¹⁷⁷ In 2005, Korean pop artist Rain played two sold-out nights at New York City’s Madison Square Garden.¹⁷⁸ *The San Francisco Chronicle* reported roughly 100,000 people tuning in to the broadcast of *Dang Jang Geum* (*Jewel in the Palace*) in the Bay Area alone.¹⁷⁹ Despite the slowing down of the Korean Wave, attention towards the phenomenon has grown. There has been a variety of coverage, including essays in the *New York Times*, which have been compiled by the Korean Cultural Service into two books: a collection of 52 articles from

2006¹⁸⁰ and a collection of 65 articles from 2007,¹⁸¹ and explorative articles such as Woongjae Ryoo's from the *Asian Journal of Communication* in 2009.¹⁸² Laura Miller, a professor of anthropology at Loyola University, published a detailed study of the Korean Wave in Japan, focusing on Bae Yong Joon and the two megahits: *Winter Sonata* and *Jewel in the Palace*.¹⁸³ A study in a 2007 issue of *Tourism Management* also found Korean dramas to have heavily influenced the increased number of tourists from Japan.¹⁸⁴ The Department of Journalism and Mass Communication at South Korea's Sungkyunkwan University also published a study that found correlating figures between the Korean Wave and its effect on South Korea's national image, resulting in higher brand equity.¹⁸⁵ This increase of attention towards the Korean Wave suggests that it is certainly still a substantial force. It is then reasonable to say that the Korean Wave is still alive. Despite its effects beginning to plateau in the countries it first passed through, Hallyu is still enjoying a high level of popularity in other regions and continuing to reach further into the non-Asian areas. The sustainability of the Korean Wave as a globalizing force will depend on the actions taking place currently in South Korea - whether or not the Korean entertainment industry can find new creative formulas, or if the South Korean government is successful in their push for the globalization of a rebranded "new Hallyu."

Notes

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LEARNING FROM MISTAKES: DECRIMINALIZING PROSTITUTION IN THE UNITED STATES

Katheryn E. Marcum

Prostitution: Problem or Profession?

Prostitution is, according to cliché, the world's oldest profession. It is also an activity greatly disputed by many, all over the world. Nearly every country has developed some way to address the issue. In the United States of America, prostitution is against the law in forty-nine of fifty states and heavily regulated in the other. The fact of the matter is that prostitution must exist because there is demand for it, and as long as that demand persists, so will the activity. Prostitution occurs across the globe between people of all genders, sexualities, ages and religions, and many other countries have decided that to fight against prostitution is futile. These countries have chosen to better distribute their resources in ways that protect all citizens. The United States should consider the successes and failures of all possible approaches to prostitution in comparison to the disrespectful, limiting, expensive and crime-ridden systems of criminalization and legalization currently in place.

According to Merriam-Webster's Online Dictionary, prostitution can be defined as "the act or practice of engaging in promiscuous sexual relations especially for money;" (promiscuous meaning "not restricted to one sexual partner") (Merriam-Webster Online 2010). This definition is, technically, correct. Prostitution is the exchange of sexual activities for a favor, usually in the form of monetary compensation, and may also be referred to as commercial sex (Law 2000, 525). Based on this definition, it is important to recognize that any sexual activity for which an individual receives monetary compensation is considered prostitution, including activities typically associated with other parts of the sex industry. Film pornography, for example, may be considered prostitution. Additionally, this limited definition does not include individuals that exchange sex not only for cash but also for other favors or gifts—transactional or "soft-sell" sex, which is common in other cultures, particularly in Latin America (Wonders and Michalowski 2001, 599). It is important to acknowledge that prostitution is not easily defined or contained, and this is part of what makes the enforcement of criminalization policies so difficult.

Two forms of prostitution will be discussed in this paper, with the acknowledgment that these represent only a small facet of the commercial sex industry. Additionally, this paper presents arguments about prostitution using a female-seller/male-purchaser scenario, as this transactional arrangement was found to be disproportionately the most frequently discussed in scholarly material due to its

prevalence in Western culture. The two forms of prostitution presented here have been chosen because they are the forms of commercial sex to which much of the legal code currently pertains. According to Sylvia Law in "Commercial Sex: Beyond Criminalization" (2000), there are three primary forms of prostitution, each with a very different economic status and clientele (529). The first form, street-walking, describes the most visible commercial sex workers (Law 2000, 529). These women, who solicit openly on the street, represent the most marginalized and the lowest class of prostitutes and are most likely to be controlled by pimps (Law 2000, 529). While these women may be the most visible and familiar, they comprise only ten to twenty percent of all prostitutes in America. Brothel workers and other off-street prostitutes (who may work in various locations such as massage parlors, hotels, and bars) comprise the middle class of prostitutes (Law 2000, 529). These women work with greater profits and discretion than streetwalkers but do not receive the benefits of the highest form of prostitution (Law 2000, 529). The largest and most socially and economically privileged prostitutes are call girls or escorts, and these women represent the largest group of prostitutes in America (Law 2000, 529). However, escorting is quite different from brothel work or streetwalking because of its hidden nature and exclusive clientele and is often addressed under separate forms of legislation. As such, this form of prostitution is not directly addressed in this paper. Each of these types of prostitution is very different, and all should be considered and accounted for in the greater legal process.

In their article "State-Sanctioned Sex: Negotiating Formal And Informal Regulatory Practices In Nevada Brothels," Brents and Hausbeck (2001) describe four primary approaches that legislative systems may choose when discussing prostitution: policies of criminalization, abolition, decriminalization, or legalization (308). Criminalization has been the preferred method in much of the United States since laws addressing such activity were created, and such legislation makes it illegal to exchange sex for money (Brents and Hausbeck 2001, 308). Legalization, another legal option, involves the organization of a system wherein workers are governed and regulated by the government (Brents and Hausbeck 2001, 308). Like criminalization, legalization does not necessarily consider prostitution a legitimate occupational choice; very often, emphasis is placed on the volatile nature of sex work and the need for additional worker regulations and protections. Abolitionist legislation classifies sex for pay as illegal and is sometimes described as a form of criminalization; however, unlike traditional criminalization which tends to blame the prostitute, abolitionist policies punish the exploiters (i.e., those individuals purchasing sex or trafficking women) while viewing prostitutes as innocent and victims of societal imbalances (Brents and Hausbeck 2001, 308). Countries that develop abolitionist policies do so because they have identified a terrible gender binary in traditional, heterosexual prostitution. The final policy option for prostitution is decriminalization, a legislative option wherein prostitution is neither illegal nor legalized but is instead treated as all other professions (Brents and Hausbeck 2001, 308). In systems of decriminalization, workers have the right to organize and receive protection under the law in the same way as other citizens.

While prostitution is considered illegal in the United States and other societies that have chosen primary policies of criminalization, prostitution is what some scholars define as a "victimless crime" (Hardway 2003, 1). Prostitution, sodomy, the use of certain illegal drugs, and other crimes are considered victim-

less by some sociological scholars because it is generally assumed that both parties choose to participate in these activities and the consequences do not directly impact the lives of other people. Victimless crimes are believed to be personal choices with personal consequences, and as such, should not be criminalized by the government.

While there are many reasons that individuals protest prostitution's status as a victimless crime, many of those who contest this characterization do so because of its association with the spread of venereal disease, a problem that does actually leave true victims in its wake. The connection between the discovery of sexually transmitted infections and societal rejection of prostitution is long established and has provided a broad arena for political and legal discourse in America. Prostitutes and the diseases they carried were blamed for many problems in the early twentieth century, from the "race suicide" that was the shrinking number of white women having children to the weakened defense of the nation due to otherwise healthy men being rejected from military service (Leichter 1991, 56-57). Today, prostitutes and those individuals who purchase sexual services have much more information and a plethora of resources to prevent and treat sexually transmitted infections. While some sexually transmitted infections have no medical cure, such as HIV/AIDS, it is unfair to blame prostitutes entirely for the spread of all sexually transmitted infections, just as it is unfair to blame any single group for their creation. If anything, the individuals who choose a system of criminalization should be blamed for creating an environment where a prostitute may not have the option to use a condom or practice safe sex, an argument that is very often overlooked when debating a prostitute's victims (i.e., male purchasers of sexual services and the so-called innocent women to whom they may spread such diseases).

In the search to assign blame for this crime, the limitations that criminalization have created are easy to overlook. In some cases, the failure to practice safe sex may not be the prostitute's but rather the result of a legal system that has created an environment that overlooks these women's welfare. Controlling pimps and violent customers may leave the prostitute with no options regarding condom use, despite her personal preference. Condom use is, however, a choice that any prostitute would most assuredly have in a legalized or decriminalized system, where basic protections and rights would be insured; in many cases, condom use is required under these systems. The United States should, perhaps, be less willing to label the men who come away from encounters with prostitutes as "victims" and instead view them as free-willed products of the democratic society in which they have a voice. The voices of the prostitutes that they visit, however, are silenced in the criminalized system, and few will argue the truth: that infected male customers also bring sexually transmitted diseases to healthy women in prostitution.

If prostitution can be viewed as a victimless crime and many of its problems as secondary to the legal environment in which sex workers operate, questions raised concerning the continued criminalization of commercial sex work gain greater validity. With the exception of the state of Nevada, the United States has always held a staunch view of criminalization regarding prostitution. The best way to determine if a change is needed, then, is to look outside the box—to compare the actual success of the current criminalization policy the other legal option being used in American, Nevada's legalized system, and also with Sweden's

abolitionist system and the decriminalized system in the Netherlands. Doing so will illuminate both the strengths and weaknesses of each system and provide information necessary to consider the future of prostitution in the United States.

The Right to Remain Silent: Criminalization in the United States

Today in the United States it is estimated that as many as five hundred thousand women have worked as prostitutes (Hardway 2003, 24). This number may seem outrageous for a country that, with the exception of just a few organized brothels in Nevada, condemns prostitution and criminalizes both the prostitutes and their clients. American prostitution policy is a combination of criminalization and abolitionist theory, holding all individuals involved in the exchange responsible for legal violations. Yet something is obviously lacking in the American approach to prostitution when, despite active searches and real punishment for the men and women involved in the prostitution industry, more than 338 million acts of prostitution occur each year (Hardway 2003, 24). Something is wrong, and whether it is in the United States' approach to persecuting offenders or in its moralistic attempt to control the sexual lives of its citizens remains to be determined.

In the United States, prostitution is technically considered a matter of the state, and each state has the right to regulate prostitution according to public opinion and legislative decisions. Currently, only Nevada has chosen to legalize prostitution in any way, and individual counties there are given the choice to allow or prohibit such activity. The regulations for brothel owners, prostitutes, and clients are very strict, especially regarding health, a primary argument for the criminalization of such activity. In Nevada, each prostitute must submit to monthly blood tests for HIV and syphilis and weekly PAP smears for gonorrhea and Chlamydia (Brents and Hausbeck 2001, 314). Employees are not permitted to work if they test positive for any of these diseases, and a 1987 Nevada law makes it a felony for a brothel worker to continue to work in the legalized sex industry if she tests positive for HIV (Brents and Hausbeck 2001, 314). Additionally, the brothels are taxed, and significant amounts of revenue are generated. In 1978, the owner of the Mustang Ranch owed an estimated \$5.6 million in back taxes—after just four years (Bode 1978, 23). The nearly \$1.4 million in yearly federal taxes was in addition to a quarterly fee of \$9,000 (\$36,000 per year), paid to the county, making the Mustang Ranch in Sparks, Nevada the county's single largest revenue source (Bode 1978, 24).

Despite the fact that the rate of AIDS among prostitutes in these legalized Nevada brothels is the lowest in the United States and that the profits made from these successful companies are taxed and used to support public services rather than organized crime, the rest of the United States still balks at legalizing prostitution (Hardway 2003, 25). Certainly one aspect that should not be overlooked in this decision is the amount of state revenue spent on prosecuting prostitutes in a criminalized system in contrast to the revenue generated by brothels in the legalized systems in Nevada. In the United States, the arrest and incarceration of each prostitute costs between \$877 per arrest in Boston to \$2,000 per arrest in New York City (Hardway 2003, 25). Considering that there are likely to be more than 100,000 prostitution arrests per year in each of these cities, the total figure of annual tax revenues lost by states due to the criminalization of prostitution is staggering—\$87.7 million in Boston alone. Even removing this fiscal burden, without considering the revenue that could be made through taxation in a more

regulated system, would greatly improve the financial security of the nation and could be considered reason enough to evaluate the system of criminalization currently in place.

Despite these figures, prostitution has always been treated as a social problem in this country; in early America it was considered a sin from which women could be persuaded to reform. The first ban on brothels went into effect in 1672, and as early as 1699 larger cities such as Boston and Philadelphia passed laws making streetwalking an offense (Hardway 2003, 151). However, while prostitution has been illegal in much of the United States since the beginning of the eighteenth century, such regulations were not often enforced by police until the anti-prostitution movements in the early nineteenth century (Hardway 2003, 151). Led by seminary students and women's groups, these movements brought the often overlooked issue of prostitution to the forefront of public concern. Divinity student John McDowall and his associates wanted to help prostitutes repent and save their souls, while the New York Moral Reform wanted to illustrate that prostitution was a direct result of the inequality between the sexes (Hardway 2003, 152). Still others, especially in England, brought forth medical research that demonized the prostitute as a carrier of contagious disease, a title that the profession has yet to shed (Gilfoyle 1999, 122).

Although these movements were unsuccessful in eliminating prostitution, the public interest they sparked about prostitution and prostitutes has only increased over time. This interest has been accompanied by the critical and intellectual movements of the twentieth century which assist in framing and understanding sensitive issues such as prostitution (Shrange 1994, xi). The discourses of postmodernism, lesbian and gay studies, critical race theory, and post-colonialism have given feminists and other activists who strive to achieve social equality new contexts with which to critically understand and appreciate the advantages and disadvantages of prostitution to all affected (Shrange 1994, xi). The polarized views of prostitution that began with the movements of the nineteenth century have expanded through these new contexts, and a multitude of feminist theoretical perspectives have been established, each of which include new analyses of prostitution and its affect on women (Bromberg 2004, 2). Feminist theory now accommodates a wide arrange of opinions about prostitution, and each of these have been expanded in order to embrace new and changing views of the prostitute, society, and the nature of sex work.

Rather than continue the trend of examining and bemoaning the symbolic "fallen woman," the depth of her depravity, and the immoral conditions of men that lead to such abuse, many historians have begun to take a much more empathetic view of prostitutes and their work (Gilfoyle 1999, 121). Beginning in the 1980s, a new wave of historical criticism has been slowly created that expresses a direct interest not only in prostitution but also in the prostitute, and, more specifically, the social and structural conditions that "situate commercial sex within the world of work and working-class culture" (Gilfoyle 1999, 121). Modern research into prostitution includes an attitude that, while perhaps not entirely accepting, upholds the humanity of sex workers and empathizes with their struggles. Some scholars appear quite concerned with the image of prostitutes that exists in history, in current culture, and that which will exist for future generations. Recent examinations of this caliber "rescue prostitution from the literature of deviancy

and crime” and integrate prostitutes in “larger historical and national narratives” in a way that has never before been possible (Gilfoyle 1999, 120). Even for those that do not believe that prostitution is a choice made entirely of free will, there is a push to challenge moralistic terminology and incorporate these sex workers into our historical and current histories in a way that assists in creating a cultural understanding.

Prostitution in the United States today is an oxymoron of incredible proportions. It is clear from statistics, however, that criminalization has not stopped prostitution—338 million acts a year (Hardway 2003, 24). means that a lot of people are buying and selling sexual favors underneath government radar, despite the risks. And criminalization has not helped local economies to prosper: at a cost of several thousand dollars per arrest, the only thing being accomplished is an inconvenience to a pimp, the destruction of a woman’s personal record, and millions of dollars in revenue being wasted for what some people consider to be a crime without any victims. Marilyn Haft, a past director of the American Civil Liberties Union’s project on sexual privacy, asserted that “Prostitution is a victimless crime [because] it is a private agreement between consenting adults” (Bode 1978, 21). If the crime has no victims, arresting those who participate only serves to create victims and to create a black-market culture that is connected to actual and dangerous crime.

While individuals such as former Boston Vice Squad Chief John Doyle may be correct in saying that “The hooker on the street these days is no longer just a prostitute. She’s a mugger, a pickpocket, a robber and worse,” it is important for Americans to recognize that prostitution may not be inherently connected with these vices (Bode 1978, 21). It could be that the system of rejection and criminalization—of persecution and arrest and degradation—has led sex workers to turn to crime. At any given moment as many as one-third of the occupants of a women’s prison has been arrested for prostitution, and seven out of every ten women arrested for a felony have been previously arrested for prostitution (Flowers 1998, 8). The criminalization of prostitution has turned the act into a gateway crime: many women arrested for commercial sex work seem to become real criminals when they are released, driven further into the subculture that surrounds their profession in an effort to survive. These statistics show that the next time these women are arrested, it won’t be for a victimless crime. Modern societies that have decriminalized prostitution, however, illustrate that such activity is not inherently associated with commercial sex work. Perhaps, then, it is the criminalization of the action that leads to the criminalization of the workers—and that this leads desperate women to do even more desperate things.

Legalization, Nevada, and the Benefits of Mind Control

Policies of legalization were developed in order to increase state intervention in the sex industry, to “control disease, violence, theft, robberies, assaults, white slavery, and other forms of social disorder” commonly associated with criminalized sex industries (Bretners and Hausbeck 2001, 308). In theory, those who support legalization believe prostitution is “an unstoppable social exchange” and believe that legalization is the best way to eliminate violence in the exchange and

protect all parties involved (Brents and Hausbeck 2005, 273). Historically, prostitution in Nevada has existed very openly, especially in rural areas, and current laws continue this trend. The legal code, known as the Nevada Revised Statutes (NRS), has several sections relating to prostitution. The first, NRS 244.245, legalizes prostitution by prohibiting “the licensing of prostitution from counties with populations over 400,000” (Brents and Hausbeck 2005, 275). In counties below this population limit, prostitution is considered a matter for local opinion, and many counties and municipalities have chosen to allow legalized prostitution. NRS Section 201.300-360 also prohibits any person from forcing or enticing a woman to become a prostitute or work in a brothel; the law also protects spouses from being forced to work as prostitutes, prevents women from being forced into marriage, and prohibits anyone from living off the earnings of a prostitute (Brents and Hausbeck 2005, 276). The legal code also provides for zoning restrictions, allowing legislators and local authorities to determine “safe distances” for prostitutes to be allowed near schools, churches, and main streets (Brents and Hausbeck 2005, 276).

While prostitution is legal in Nevada, it is important to acknowledge that the tightly structured and rural nature of such activity has its downfalls, as indicated in the high levels of prostitution that occur outside these legal brothels. Many of the state’s prostitutes work independently and illegally in the much larger cities of Reno and Las Vegas. In her book *Prostitution and Trafficking in Nevada: Making the Connections* (2007), Melissa Farley describes the results of two-year research study regarding legalized prostitution in Nevada in grim detail. In addition to discovering that only about ten percent of prostitution occurs in legal brothels, Farley discovered that many of the frequently cited positives of legalized Nevada prostitution are, in fact false (13). Throughout the study, Farley discovered that legal and heavily controlled prostitution does not necessarily protect women from violence, verbal abuse, physical injury, or sexually transmitted disease, and that women in legal brothels are placed in situations of extreme emotional stress and frequently “exhibit symptoms of chronic institutionalization and trauma” (13). It is clear that, even though this form of prostitution appears safer and more controlled than that which exists in the criminalized sector, it is still imperfect and perhaps even more harmful to sex workers.

Proponents of the legalized system in Nevada may point to it as the ideal standard for the rest of the United States and cite the need to protect these women as the primary goal. Scholars argue that these brothels were created to temper the violence associated with prostitution, of which there are three primary types: interpersonal violence against prostitutes, violence against community order, and the violence of disease (Brents and Hausbeck 2005, 277). Many assert that there is no better way to insure the safety of both sex workers and their clients than to monitor and control the conditions in which these transactions take place. The implication behind this rhetoric is that the nature of commercial sex leaves the sex worker in a very vulnerable position, in which she must be protected from community members who do not support her actions, violent customers and men who may violate her will, and disease. Individuals involved with the Nevada system defend it as “the most reasonable way to regulate sex as commerce,” asserting that its legality prevents an inherent association with criminal activity and creates an environment in which the prostitute and clients are safe (Farley 2007, 13).

The truth, however, lies in the fact that Nevada's legal brothels are not the pleasant and safe communities brothel owners would like outsiders to believe. They are not safe havens wherein workers gain fair wages, work in clean buildings without fear of violence from customers, and are protected from disease and mistreatment. A close examination of current Nevada brothels leaves little doubt regarding the decision of prostitutes who choose to work outside the system. The fact that many sex workers would rather work in the criminalized system where they face a real risk of arrest and, perhaps, sexually transmitted infections, should indicate a disconnect between the illusion presented to the public and the reality of legalized Nevada brothels.

A Nevada brothel may be easily mistaken for a prison, and the chain-linked fences covered with barbed wire surely serve to keep people in rather than keeping them out (Farley 2007, 16). The women that work within these systems have been described as "brainwashed and imprisoned," and their every word and action is monitored by other employees through electronic surveillance (Farley 2007, 16). They are confined to the compound unless given express permission to leave—and then they must be accompanied by an escort whose time they are required to pay for (Farley 2007, 18). Here, women are frequently treated "like machine[s]," viewed as prisoners and treated as potential revenue; their entire lives are scripted by the pimps and madams, down the amount of food they receive each day (Farley 2007, 17). This information appears to negate claims that legalization "eliminates the universally abusive pimp-prostitute relationship," and indicates the opposite: that these relationships are at times even worse than in the criminalized system because of the sheer control that pimps and madams are given over these workers, sanctioned by state and local officials (Bode 1978, 24).

Conversations with Nevada's prostitutes show that these women are also aware of the way they are viewed by their managers, and many indicate that the safety so often touted as a primary reason for legalization is nothing but a myth. During research for their 2005 article "Violence and Legalized Brothel Prostitution in Nevada: Examining Safety, Risk, and Prostitution Policy," Barbara Brents and Kathryn Hausbeck spoke with prostitutes from thirteen of Nevada's twenty-six brothels, and their comments about their perceived safety as presented in the article are quite shocking (271). While these women appreciate the way that Nevada's brothels handle the negotiation process by allowing them to negotiate early and quickly separate money from the transaction, some women believed that their personal safety was not always the first priority of the brothel owners, especially after the money had been received. One woman said that the baby monitors placed in the rooms for protection were "a real false sense of security" because "they're not always listening" (271). Similar complaints were raised about panic buttons in the rooms, a safety feature in all the brothels visited by Brents and Hausbeck. A prostitute interviewed said that "panic buttons are a joke" because they are usually located across or even outside the room, making them difficult or even impossible to reach in a dangerous situation (280). Brothel owners interviewed during the same research process, however, insist that their primary concern is their ladies' well being, and that, due to legalization, the women are safe in their brothels and have access to police and other forms of protection (281).

Despite this assertion, there is evidence that big-city pimps in the criminalized sector work with legal brothel owners to exert greater control over the

lives of “their” women. One pimp described a brothel as a sort of personal prison camp, where other pimps could drop off women and they would be forced into cooperation (Farley 2007, 16). If legalized prostitution is connected with illegal prostitution, it can be inferred that it is also connected with the organized crime with which prostitution has become so firmly associated, resulting in a failure in the Nevada system to protect these women from at least one element of the violence from which they claim to shelter them. Additionally, these women aren’t making the impressive earnings that Americans would be led to believe: they are financially exploited just as sex workers in the criminalized system are, and they are required to forfeit as much as fifty percent of their earnings to pimps or madams (Farley 2007, 19). After being required to tip brothel employees, pay gouged prices for rent, and receive no employment benefits or health insurance, women in this industry are lucky to keep one fifth of the money that they earn (Farley 2007, 19).

In her book, Melissa Farley asserts that many of the problems with legalized prostitution occur because of society’s rejection of prostitutes as complete human beings and argues that these women understand that they are devalued (Farley 2007, 15). She believes that this social rejection leads them to hide their status as prostitutes and that no prostitution theory will remove this social stigma and willingness to hide unless the entire social system is reworked. Reworking the entire system would be an impossible task and one that leads Farley to therefore assume that prostitution will never be a desirable, respected, nor healthy profession, and certainly not in a legalized system. While Farley does have a point in the argument that American society does reject prostitutes, and is also correct in her assertion that these women know the marginalized place they hold in society, this is not necessarily a characteristic inherent in the commercial sex industry but likely a product of deeply established cultural attitudes. The majority of the United States has criminalized prostitution and therefore treats prostitutes as criminals; Nevada’s legalized system is no different with its state-sanctioned brothel-prisons. Even in Nevada’s legalized system, prostitutes are not given the opportunity to become valued citizens. Instead, they are cloistered in brothels, kept away from the rest of the public and abused beneath the watchful eye of the state.

Sweden’s Kvinnofriod: All Prostitution is Violence

There are very serious flaws in the United States’ current prostitution policies of criminalization and Nevada’s policy of legalization. Based on this evidence, legislators and citizens must seriously consider reworking policy to better benefit communities, sex workers, and the general goal of public health. In order to determine the best legal options for the United States, citizens and legislators should consider policies that approach prostitution from a different tactical direction. Legislative options that rely more heavily on abolitionist and decriminalization rhetoric should be examined in an effort to determine the best new approach for the United States.

Sweden is a country that has taken a very different approach to prostitution, and the Swedish version of a pure abolitionist policy may be the first in world history. Sweden, a country committed to gender equality, identified many prob-

lems in societies that have legalized, criminalized, or decriminalized prostitution. These failures are, from the Swedish perspective, caused from the gross gender inequality that exists in the female-seller/male-purchaser prostitution binary and the violence inherent in such activity. In response, the Swedish government drafted and passed a bill designed to completely remove such inequality. The Swedish government established the Commission on Prostitution in 1977 to analyze prostitution practices and policies in Sweden, and in 1995 the group developed a new approach to prostitution which has become the new legal standard in Sweden (Hubbard, Matthews and Scoular 2008, 143).

In July of 1998, the *Kvinnofriod Act* was passed. This legal motion, also known as the "Violence Against Women Act," is an entirely abolitionist approach to commercial sex work (Hubbard, Matthews and Scoular 2008, 143). Rather than punishing those women who sell sex, the *Kvinnofriod Act* criminalizes the purchase of sex. The document states that "a person who obtains a casual sexual relation in return for payment will be sentenced...for the purchase of sexual services to a fine or a term of imprisonment not exceeding six months" (Hubbard, Matthews and Scoular 2008, 143). While the United States and other countries incorporate elements of abolitionist theory into their criminalization policies by punishing those who purchase sex as well as those who sell it, Sweden is unique in that the *Kvinnofriod Act* does not criminalize the sale of sex in any way. In Sweden, it is completely legal to sell sex; it is also, however, completely illegal to purchase it (Sullivan 2009, 10). Upon the development of this legislation, Swedish officials from the Ministry of Industry, Employment and Communications explained the choice of abolitionist policy by stating that "Gender equality will remain unattainable so long as men buy, sell, and exploit women and children by prostituting them" and that "by adopting the legislation Sweden has given notice to the world that it regards prostitution as a serious form of oppression" (Hubbard, Matthews and Scoular 2008, 143).

There have been major improvements with the addition of the law. According to research, the number of women in prostitution dropped nearly 40% within the first five years after the law's enactment, a major goal of the legislation ("Sweden" 2008, 7). There is also research to indicate that the presence of the law has changed the attitudes of the public, particularly young men, toward prostitution by illustrating its prostitution's inherent negative treatment of women (Sullivan 2009, 10). Additionally, the presence of the law has deterred traffickers, an especially important action. The number of trafficked women in Europe has grown steeply in recent years, and now many countries are being forced to evaluate their prostitution policies. Police overhear traffickers commenting that they avoid Sweden because it's "a bad market," and the Swedish people should consider this a victory in the fight against human trafficking ("Prostitution" 2007, 12).

While the attitude behind the *Kvinnofriod Act* is commendable and the successes to be praised, there are many flaws in the Act's rhetoric and execution. It is the intention of the *Kvinnofriod Act* to criminalize the purchase of all sexual activity, including specifically those services sold on the street, in brothels, in massage parlors, and from escort services (Hubbard, Matthews and Scoular 2008, 143). As previously discussed, however, these services are just a fragment of what can actually be considered commercial sex, and authorities have difficulties separating what is legal from what is not (Hubbard, Matthews and Scoular 2008, 143). Additionally, much

of Sweden's prostitution is mobile, with sellers and purchasers connected electronically through the internet and cellular phones, making them difficult to track down (Sullivan 2009, 10). Perhaps the biggest problem that critics find with the Kvinnofriod Act is the lack of punishment for those who violate the law. Some studies indicated that as of 2009, a decade after the law was put in place, over 2,000 arrests had been documented but not one individual had been jailed and even convictions had resulted only in minor fines, a phenomenon blamed on the low maximum penalties listed in the law (Sullivan 2009, 10). Critics have also charged Sweden and the Kvinnofriod as a law that has not helped prostitutes themselves. Susan Dodillet, the author of the controversial study "Is Sex Work?," investigated Sweden's law and commented on the discrepancies, saying that "Since it came into force, nothing has been done to improve the situation for women in prostitution" (Sullivan 2009, 10).

The Swedish government has not ignored critical remarks, however, and has instead seriously considered them in an attempt to make their system of abolition a new world standard. In 2008, the government adopted a new "36-point plan" to improve the Kvinnofriod Act. Legislators have pledged \$35 million to institute these measures which include an expansion of the social services available to prostitutes, an increase in police activity and legal persecution of pimps, johns and traffickers, and the training of medical and social service employees to better identify and assist in suspected cases of prostitution and trafficking ("Sweden" 2008, 7). The Swedish government is truly trying to establish a society that will be free from gender inequality and violence toward women, and they believe that a policy of abolition is the best way to combat these attitudes. Other countries, such as Norway and Iceland, agree with the Swedish model, and have recently developed their own versions of the Kvinnofriod (Sullivan 2009, 10).

Although imperfect, the Swedish model does offer a very different approach to classical criminalization policies which demonize the woman in prostitution. This information indicates, however, that pure abolitionist theory is far from perfect, and many of the changes that are being implemented in the "36-point plan" are social programs that have been established in countries with policies of legalization and decriminalization. Additionally, the abolitionist perspective, in an attempt to establish a society with complete gender equality, may be viewed by some as "paternalistic" and "disempowering to women" because of its tendency to view them as victims who require special protections (Bretns and Hausbeck 2005, 273). Abolitionist theory assumes that prostitutes are victims in instances of transactional sex and, while this may be preferred to a criminalized status or oppressive legalized system, this perspective does not account for women's freedom of choice. Rather than legitimizing the woman and her work, abolitionist theory establishes one as weak and the other as repugnant in civilized societies, a view which ultimately limits women's rights to sexual freedom and autonomous ownership of their physical bodies.

Sweden's attempt to abolish prostitution through the criminalization of the purchase of sex, while commendable, cannot be the solution to the problem of sex work in the United States. In order for prostitutes and sex workers to be accepted in society and for women to move toward complete ownership of their bodies, commercial sex must be accepted as a profession: it must be viewed as equal work with equal pay. Other countries, such as the Netherlands, have had success with models of decriminalization and have proved that while it is impos-

sible for all citizens to agree on the moral issues surrounding sex work, it is possible for sex workers to fit into society in a way that they have not been able to in American systems. The social stigma that Melissa Farley believes to be permanent is, in fact, a matter of acceptance that must come from the governmental level. Although Farley believes that acceptance cannot come from any established policy, previous attempts have proven that legitimizing the work can go a long way in legitimizing the worker in the eyes of a resistant public

Decriminalization or the Right to Pay Taxes

The 1970s was a decade of rebellion and reform in America, and many groups moved forward in the fight for tolerance and equality. The Women's Movement and Gay Rights Movement were primary movements in the search for equality in American culture. Another, lesser-known group was working just as diligently on the sidelines, however. Along with these two major movements came the Sex Workers' Rights Movement, led by an organization called Call Off Your Old Tired Morals (COYOTE) and a former prostitute, Margo St. James (Weitzer 1991, 24). The movement and COYOTE began in San Francisco when a group of sex workers decided that it was time to fight the system. They believed that prostitution was legitimate employment and a part of the rights of sexual determination given to all citizens. These women believed that they should have the right to control their own bodies, and that this included exchanging sex for money or other favors (Weitzer 1991, 24). Unfortunately, a lack of proper organization and a failure to secure direct support from other, more powerful groups led to the ultimate failure of the movement's primary goals—to educate the public about the social inequalities perpetuated through the current system of criminalization and to increase awareness and support of a system of decriminalization (Weitzer 1991, 25).

While the Sex Workers' Rights Movement in the United States may have failed to meet its goals, other countries have embraced the idea of decriminalization and vindicated the rights and independence that American sex workers have sought. The system of decriminalization in effect in the Netherlands is one of the most well-established in the world. While the Netherlands is often described as "a place where anything goes," Christje Brants suggests in her article "The Fine Art of Tolerance: Prostitution in Amsterdam" (1998) that the decision to decriminalize prostitution in the country was an important one not easily made. According to Brants, what the rest of the world sees as a Dutch willingness to overlook crime is actually a carefully developed method of dealing with controversial issues in the complicated Dutch legal system (624). The Netherlands's liberal policies are not evidence of a country that has no rules but rather the result of extreme compromises in a complicated political climate wherein many different parties vie for dominance, particularly conservative religious groups (624).

The Netherlands has always been known as a place where prostitution was common; the "Red Light Districts," so popular in the 1960s and '70s, are world famous. But prostitution was, until very recently, illegal in the Netherlands and existed in a system known as *geoden* or "pragmatic tolerance," the non-persecution of criminal offenses (Brants 1998, 624). *Geoden* is a method of social control that has been popular in the Netherlands and Dutch culture for several hundred years.

Basically, prostitution has been considered a crime in the Netherlands for much of the nineteenth century, but offenses were differentiated and diverted through the criminal justice system because of conflicting social views on the subject. Unlike the United States, the Netherlands has never held a standard criminalized view of prostitution but instead adopted a more abolitionist approach throughout history, criminalizing anyone living off of or organizing prostitution (Kilvington, Day and Ward 2001, 81). Through this system, prostitution could be both visible and illegal through the careful management of legal code, and prostitutes themselves were not targeted by authorities.

Although the Dutch legal system may be complicated and evasive, the Dutch view of prostitution is straightforward and based on long-held beliefs. Although prostitution may not coincide with all aspects of moral belief in the Netherlands, it has always been seen as necessary, and Dutch law throughout the centuries has followed this belief. A 1413 Amsterdam law expressed a belief in the necessity of prostitution, especially in larger cities, based on the theory that “the holy church tolerates whores on good grounds” and that “for these reasons the court and sheriff of Amsterdam shall not entirely forbid the keeping of brothels” (Brants 1998, 626).

Even though the Dutch have had a historically accepting view of prostitution, the current policy of decriminalization struggled to gain voter acceptance. The decriminalization of prostitution in the Netherlands was only approved after an ongoing political campaign lasting more than fifteen years (Brants 1998, 626). Current legislation, passed in 2000, legalizes brothels as long as the businesses are discreet and do not interfere with public life, and legitimizes prostitution as a profession in an attempt to remove the social stigma from which the women in this industry suffer (Kilvington, Day and Ward 2001, 82). Although there are specific regulations applicable to the now-legitimized sex industry, they have been put in place in an effort to secure quality of life for sex workers and to prevent human trafficking. For example, the new legislation requires that all brothels meet certain size requirements and provide certain standard amenities for workers, such as hot and cold running water (Kilvington, Day and Ward 2001, 82).

Although all of the aims of the new law in the Netherlands have yet to be realized, conditions for sex workers have shown extreme improvements. The introduction of health and safety regulations, the ability of workers to operate as part of public life, the right to access health services, pensions, and register as self-employed persons are all improvements and rights that have changed the nature of prostitution and sex work in the Netherlands for the better (Kilvington, Day and Ward 2001, 84). And, although the decriminalization of prostitution has not completely removed the stigma placed on sex workers, conditions have been greatly improved, especially after sex workers were required (or granted the opportunity, depending on perspective) to pay taxes, thus legitimizing them as contributing and productive members of the community (Wonders and Michalowski 2001, 554). Such a seemingly small, perhaps inconvenient thing, has greatly improved the public perception of sex workers, who can now be seen as contributing community members with the same rights, entitlements, and governmental treatments. These women are now true “sex workers,” and this is slowly changing their image—even in a country as tolerant as the Netherlands.

While the decriminalization policy is not without flaws, the problems are less related to prostitution and more connected with social and economic prob-

lems that are affecting all world communities. Because the new legislation has given prostitution legal employment status, only those individuals eligible to be legally employed in the Netherlands are able to register and gain benefits. This means that underage sex workers, those who are addicted to drugs, and illegal immigrants are not covered under the new system, and have been forced to operate beneath the radar of the law (Kilvington, Day and Ward 2001, 86). While these exclusions are problematic and have resulted in an increase in illegal prostitution, they are secondary issues not caused by the new decriminalization policy. Indeed, problems such as illegal immigration and delinquent youth plague all societies and are issues that the Netherlands is attempting to solve independently in an effort to prevent the same criminal associations with illegal prostitution often seen in countries with criminalized policies. The benefits of the decriminalized system to legal prostitutes have been vitally important to individual self esteem and personal safety, and successful systems of decriminalization work to change not only the negative opinion of sex work in the country in which they are instituted, but it the world. These systems allow prostitutes to be meaningful members communities, and to regain in part the sense of worth so often lost because of societal prejudices.

Sex is the Word

While there are some feminists who believe that no policy of prostitution will ever be perfect, current policies of criminalization in the United States clearly benefit some groups while detrimentally impacting others—namely, benefiting “those in society who find the exchange of sex for money morally reprehensible and a threat to the family order” (Hayes-Smith and Shekarkhar 2010, 46). Those women who find themselves working in the sex industry are looked down upon by a society that has, perhaps, been conditioned to assimilate certain religiously-based moral beliefs. It is also obvious from statistics that the primary assumptions behind the current policies of criminalization and legalization contain obvious fallacies: criminalization of prostitution does not prevent the solicitation of such services; prostitutes are neither the sole cause of nor the reason behind the spread of all sexual diseases; prostitution is not inherently related to violence against women, but such violence is instead a product of the subculture caused by illegality (Hayes-Smith and Shekarkhar 2010, 44-45). Sweden’s approach, too, leaves much to be desired in the way it victimizes women and prevents the entire population from taking complete control of their bodies. Countries like the Netherlands prove that, in policies of decriminalization, prostitution does not disrupt the community order, harm children, or lead to public harassment or violence against women (Hayes-Smith and Shakarkhar 2010, 45).

Decriminalization is not perfect, and there are real problems associated with its introduction into a culture. Questions about prostitution legislation should not be framed “What are the problems?” but instead “What problems can this solve?” The answer to this question is simple: decriminalization is a step toward the acceptance and tolerance so badly needed in the lives of these women. The answer is a solution to the discrimination and hatred that they feel walking down the street, the judgment that this culture passes upon them as criminals, ob-

jects and impediments to societal perfection. One bondage and discipline worker described what she hoped might happen in a decriminalized system quite concisely, stating: "It might change the way people perceive or think about sex workers ... because that would kind of start to heighten people's awareness about how this moral stigma has affected us" (Reproductive Health Matters 2009, para. 32).

The truth about prostitution in America—both legalized and criminalized—is disturbing, and continuing to ignore the problems in the current legislation will not help anyone. There are real issues here which affect the public and especially the workers, and the current policies of legalization and criminalization are placing women involved in street work and brothel work in dangerously marginalized positions. The evidence presented here proves that criminalization has not decreased instances of prostitution, and indicates that such legislation may in fact have led to an increased delinquency rate among these women. Criminalization has also fostered an attitude of distrust regarding commercial sex workers, whose profession has been determined immoral and a risk to the public and American family. Legalization, despite what proponents may suggest, does not provide workers with more rights or protect them from the drugs and crime associated with pimps in the criminalized system. These women are treated much worse; not only are their entire lives controlled by pimps posing as business owners, the local governments are aware of these injustices and allow them to continue. The communities in which brothels are located shun sex workers and enforce demeaning segregation rules which go against the basic ideals of a country that promotes freedom and equality.

Countries such as the Netherlands have shown the world, however, that the legitimization of commercial sex workers does not mean an end to the family unit or chaos to the society. In fact, the decriminalization of sex work provides a solution to many of the problems associated with criminalization and legalization. Workers retain their rights and independence but are offered benefits individuals outside the industry take for granted, such as the right to unionize, to seek legal protection and to obtain health care. Approving commercial sex as an acceptable career choice also goes a long way in improving the self-esteem and public image of the women that choose to seek employment in such a field. Instead of being treated as criminals, objects, or victims, these women have the opportunity to become valued members of society. As illustrated in the Netherlands, the opportunity to pay taxes the way other citizens do can go a long way in improving sex work in the eyes of the public and participants.

Citizens, legislators, and sex workers in the United States should consider the benefits of the decriminalization of sex work, and evaluate the potential benefits that it offers to society. Not only could such legislation improve the crime rate and fiscal spending of the entire country, but decriminalization could be the chance to prove to all American citizens that this truly is a country that values personal choice and equality. It is time to look at the facts, learn from mistakes, and move forward. As Sweden has discovered, commercial sex work will not disappear any time in the future, and an unwillingness to face facts not only harms women that work in this industry but society as a whole. It's time to move past old prejudices and look toward a new future where safety is guaranteed, respect is encouraged, and equality is an inalienable right.

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PHYSICAL & NATURAL SCIENCES

ACTIVITY AND STABILITY STUDIES FOR ENZYME-NANOMATERIAL CONJUGATES

Alan Campbell, Thomas Sobray, Chenbo Dong, Gabriela Perhinschi, Cerasela Zoica Dinu*
Department of Chemical Engineering, West Virginia University, Morgantown, WV 26506

Introduction

Recent advances in nanomaterials synthesis and engineering have made an impact on a number of fields. For instance, in nanoelectronics, single walled carbon nanotubes have been used as thin-film semiconductor for miniaturized transistors (Kang 2007), while in photonics, biology or medicine carbon nanotubes have been investigated as highly specific biomolecule detectors (Chen 2003; Kempa 2003; Liu 2009). Other nanomaterials, such as titanium dioxide, had shown a strong ability to decompose water into oxygen and hydrogen and were used for cancer treatments (Kubota 1994). By interfacing nanomaterials with biological molecules novel applications have emerged ranging from diagnostics, to drug delivery and biosensors (Jain 2007; Bianco 2005; Scuhmann 2000). For these applications, various methods were used to prepare biological molecule-nanomaterial conjugates including physical immobilization (Bake 2010) or covalent binding (Arica 1995). However, few of these studies have described how the nanomaterial influences the structure and function of the protein with which it is interfaced.

Enzymes have many advantages over their chemical counterparts in that they are specific, possess high catalytic power, and are environmentally friendly (Shield 1986; Schmid 2001). Enzyme biotechnology has applications in food processing (Motoki 1998), biofuel (Minteer 2007), and brewery and paper industries (Bhat 2005). However, the major problem associated with the practical application of enzymes is their limited storage and operational stability (Mateo 2007). This research focuses on studying the behavior of the enzyme soybean peroxidase (SBP, a model enzyme) on two classes of nanomaterials, namely multi-walled carbon nanotubes (MWNTs) and titanium dioxide nanotubes ($\text{TiO}_2\text{-NT}$), in view of understanding how nanomaterials influence the function of the protein with which they are interfaced. The nanosupports were chosen based on their broad applications (Kang 2007; Kubota 1994, Bahnemann 2004; Borkar 2010). Moreover, the chosen nanosupports have high surface-volume ratios that allow relatively high enzyme loading and ease of recovery of the enzyme-nanomaterial conjugate by filtration. SBP was immobilized either through physical or covalent binding, and the enzyme-nanomaterial conjugates were subsequently characterized in terms of loading and activity. The enzyme loading represents the amount of enzyme attached to the surface of the nanosupport, while the retained activity is a measure of the activity of the immobilized enzyme, relative to free enzyme in solution. Further characterization of the enzyme-nanomaterial conjugates using scanning and electron microscopy revealed the presence of individually dispersed enzyme-nanomaterial conjugates. These next-generation conjugates provide a simple

method for the assembly of unique bionanoconstructs to find applications in novel device technologies where biocompatibility between inorganic nanomaterials and biological scaffolding is crucial.

Experimental

Materials

Multi walled carbon nanotubes (MWNTs, 10-20 nm diameter, 5-20 micron in length, purity > 95%) were purchased from NanoLab, Inc. (Newton, Ma). Sulfuric acid (H₂SO₄, 95-98%), nitric acid (HNO₃, 68-70%), and dibasic potassium phosphate were purchased from Fisher Scientific. Titanium dioxide nanobelts (TiO₂, 60-300 nm in width, ~10 nm thick, several microns to 30 mm in length) were provided by Dr. Nianqiang (Nick) Wu – Associate Professor at West Virginia University (WVU). Soybean peroxidase (SBP) was purchased from Bio-Research Products, Inc. Isopore filter membrane (pore size 0.2 μm, type GTTP, polycarbonate) was purchased from Millipore (Billerica, MA). 1-(3-Dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (EDC, 98+%), N-Hydroxysuccinimide (NHS, 98+%), and monobasic potassium phosphate were purchased from ACROS Organics (Morris Plains, NJ), while 2-(N-morpholino) ethanesulfonic acid sodium salt buffer (MES) and hydrogen peroxide solution (30%) were purchased from Sigma (St. Louis, MO). 2,2'-Azinobis [3-ethylbenzothiazoline-6-sulfonic acid] (ABTS) and BCA protein kit were purchased from Pierce (Rockford, IL). The formvar-coated carbon grids and the carbon grids were purchased from (Electron Microscopy Sciences, Hatfield, PA).

Methods

Cutting of MWNTs

100 mg of MWNTs were cut in a single batch. The tubes were placed in a 1-L Erlenmeyer flask and suspended in 400 mL of a 3:1 mixture of H₂SO₄ and HNO₃, respectively. The solution was then sonicated using a Branson ultrasonic bath (115 Vac, 60 hz) in ice and in a hood for the required time (i.e., 3 hr, or 6 hr). Throughout sonication, fresh ice was added to the bath. Once the allotted time period had passed, the solution was removed from the sonicator and gradually diluted with constant swirling into an Erlenmeyer flask containing 900 mL of ice-cold milliQ water; heat dissipation was allowed (for ~10 min). The solution was then filtered through the GTTP 0.2 μm polycarbonate filter membrane and washed extensively with milliQ water to remove any residues. The mass of MWNTs remaining on the filter membrane was then redispersed in 1000 mL milliQ water and the filtering process was repeated 4-6 times with a new filter membrane every time until water-soluble MWNTs were obtained. The washed tubes were placed in a glass vial and stored at room temperature.

Enzyme Immobilization by Physical Adsorption

1 mg/mL enzyme solution was prepared in phosphate buffer with a pH of 7. 1 mL of the solution was then added to 1 mg of the MWNTs or TiO₂. The mixture was briefly sonicated to disperse the nanosupport and incubated with shaking at 200 rpm for 2 hours at room temperature. The immobilized enzyme was recovered by filtration on the GTTP 0.2 μm polycarbonate filter membrane. The supernatant was isolated; subsequently, the conjugates on the filter were washed at least six times (1 mL for each wash) to remove loosely bound enzyme. The supernatant and the first two washes were kept and used to determine the concentration of the protein.

Enzyme Immobilization by Covalent Binding

Enzyme was covalently attached to the nanosupport via a two-step process involving EDC/NHS activation chemistry followed by enzyme coupling. Specifically, 2 mg sample of the MWNTs or TiO₂-NTs were dispersed in MES buffer (2 mL, 50 mM, and pH 4.7) containing EDC and NHS (160 mM and 80 mM, respectively) by brief sonication. The solution was then incubated at room temperature with shaking at 200 rpm for 15 min. The solution was subsequently filtered through the GTTP 0.2 μm polycarbonate filter membrane and thoroughly washed with MES buffer. The activated nanosupports were immediately used in the enzyme coupling reaction. The nanosupports were dispersed in the required buffer solution (e.g., 1 mg/mL SBP in phosphate buffer) and the enzyme coupling was allowed to proceed for 3 hr at room temperature with shaking at 200 rpm. The immobilized enzyme was recovered by filtration using the GTTP 0.2 μm polycarbonate filter membrane and the supernatant was isolated. The conjugates on the filter were then washed with the necessary buffer six times, 1 mL for each wash to remove loosely bound enzyme and the first two washes were kept.

BCA Assay

The concentration of enzyme in the washing solutions or supernatants was determined using the standard BCA assay. Briefly, the working reagent was prepared by mixing 50 parts of reagent A (i.e., 1 mL; the reagent A contains sodium carbonate, sodium bicarbonate, bicinchoninic acid and sodium tartrate in 0.1 M sodium hydroxide as specified by the manufacturer) with 1 part of reagent B (i.e., 20 μL; the reagent B contains 4% cupric sulfate as specified by the manufacturer). Both reagents A and B were provided in the BCA commercially available kit. 50 μL of each washing or supernatant solution to be examined was then added 1 mL of the working reagent and incubated in a water bath at 37°C for 30 min. Each sample's absorbance was then monitored at 562 nm using the UV-Vis spectrophotometer. Standard calibration curves were prepared using the corresponding purified enzyme and serial dilutions (from 1 mg/mL to 0.03 mg/mL in the phosphate buffer). The enzyme loading onto the nanosupport was determined by the difference between the initial amount of enzyme added in the immobilization process and the total amount of enzyme washed out, i.e., in the supernatants and washings.

SBP Activity Tests

The activity of SBP was measured by monitoring the oxidation reaction of ABTS in the presence of H_2O_2 . 10 μL of immobilized enzyme dispersion (original concentration: 1 mg/mL of nanosupport; enzyme loading determined by BCA) was added to 0.65 mL of ABTS solution (in phosphate buffer, pH 7.0, concentration 0.250 mg/mL), and then 20 μL of H_2O_2 solution (6.5 mM) was added to initiate the reaction. The increase in absorbance was then monitored at 412 nm on the UV-Vis spectrophotometer. As a control, the activity of free SBP at the same concentration found in the sample being tested was also quantified. The activity of the conjugates was reported by normalizing to free SBP activity as 100%.

Microscopy

Nanotube samples were analyzed using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). SEM images were obtained at West Virginia University with a Jeol Scanning Electron Microscope operating at a pressure ranging from 30 to 70 Pa and at accelerating voltages of 5 kV. TEM images were obtained at Rensselaer Polytechnic Institute with a Philips CM-12 Transmission Electron Microscope at 120 kV. Typically, the nanomaterial solution in water (10 μL of 0.1 mg/ml) was dropped onto carbon-coated grid (from Electron Microscopy Sciences, Hatfield, PA), while the enzyme-nanomaterial conjugate solution in water (10 μL of 0.1 mg/ml) was dropped on a Formvar carbon-coated grid (from Electron Microscopy Sciences, Hatfield, PA) and then exposed to a 0.5% solution of uranyl acetate for 3 seconds. The samples were vacuum-dried overnight prior to TEM imaging.

Results and Discussion

Bionanoconjugates of SBP-MWNTs and SBP-TiO₂-NT were prepared by physical and covalent binding respectively (**Scheme 1**). For physical binding, SBP was incubated at room temperature with either MWNTs or TiO₂-NTs, while in covalent binding the enzyme was immobilized onto nanotubes using EDC/NHS coupling chemistry (Phadtare 2003). To reduce the intrinsic hydrophobic-hydrophobic interaction among individual carbon nanotubes and thus reduce nanotube-bundle formation, we used acid functionalized carbon nanotubes. Acid functionalization for 3 and 6 hr yielded free carboxylic acid groups onto the carbon nanotube surface and resulted in increased nanotube solubility in water (**Scheme 1c**) (Dinu 2010).

The amount of the SBP immobilized through either physical or covalent binding onto the nanosupport (carbon or TiO₂) was quantified using BCA protein assay and the data is shown in Table 1. The activity of the conjugates immobilized on supports of carbon or TiO₂ was tested using standard spectroscopic ABTS oxidation assay and monitored at 412 nm (**Table 1**) and reported relative to the activity of the free enzyme in solution. Both the loading and activity are reported in terms of mean standard deviation and the data is averaged over at least 5 samples in order to assure relevant statistics.

The presence on enzyme immobilized onto the nanosupport (either carbon or TiO₂ nanotube) was confirmed using electron microscopy as shown in **Figure 1** and **Figure 2** respectively. **Figure 1b** clearly indicates that the SBP (in the form of dark spots as pointed by the arrows) was attached onto carbon nanotube all over its surface while **Figure 2b** shows SEM images of TiO₂ tubes embedded in a mass of SBP protein (both when compared with bare tubes).

This is the first study to report on the comparison between the loading and activity of SBP immobilized onto MWNTs and TiO₂-NTs respectively. We observed that the loading and activity of the SBP enzyme is strongly dependent on the nanosupport used during the immobilization. SBP (40 kDa) has an isoelectric point of 4.1. (Gray, 1996). At a working pH of 7, the protein is negatively charged thus with a higher affinity for hydrophobic surfaces. This explains the highest loading as reported for the MWNTs that possess intrinsically hydrophobic walls, while the TiO₂-NTs are highly hydrophilic and would repel the SBP in solution thus explaining the low loading quantified. Moreover, previous studies by Phadtare and Schumann have also shown that the surface curvature plays a role in the immobilization of enzymes and their activity at the interface with a nanosupport (Jain 2007; Phadtare 2003). The curvature effect is illustrated in **Scheme 2**. With a lower curvature more of the enzyme will come in physical contact with the surface of the nanosupport, thus causing increased deformation and lower activity; however, the enzymes will be more spread out, reducing unwanted protein-protein interactions.

Our results provide the opportunity to compare two different nanosupports for the first time in order to derive potential means to control enzyme-nanomaterial interface. Further studies will concentrate on increasing enzyme activity at the nanosupport (i.e., by means of spacers or enzyme crosslinking with chemical agents) (Dinu 2010), and on studying the structural integrity of the enzyme and how this is influenced by the surface properties of the nanosupport and the interface reactions.

Conclusions

Enzyme attachment onto nanosupports of carbon and TiO₂ was confirmed by electron microscopy and loading was quantified by BCA assay. The activity of the enzyme at the nanotube support was measured using standard spectroscopic assays. The activity and loading is reported in relation to the surface properties and curvature of the nanotube support used during immobilization.

Acknowledgments

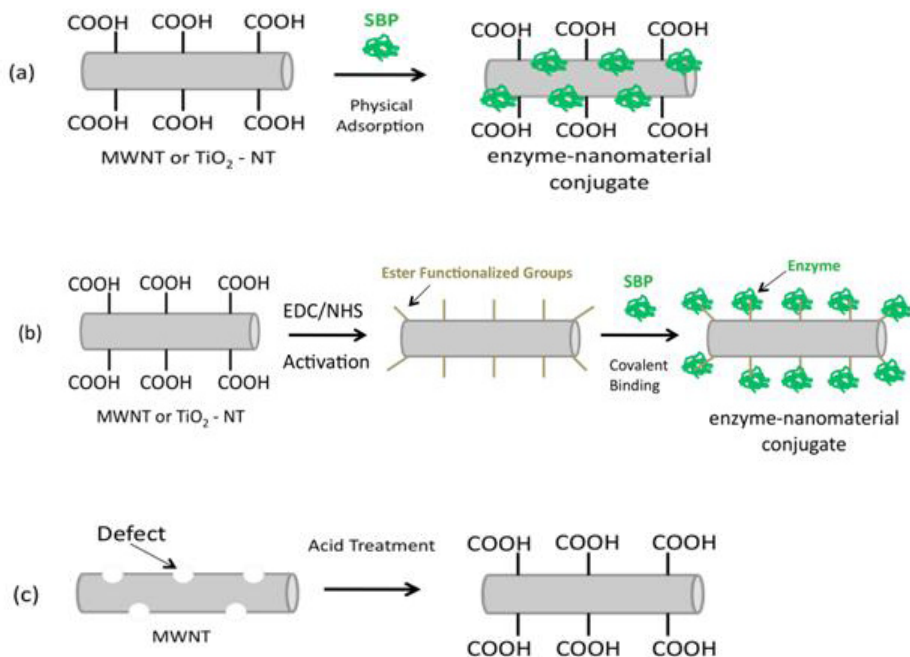
The authors thank Dr. Nianqiang (Nick) Wu - Associate Professor WVU, WVNano, Department of Mechanical & Aerospace Engineering and Chengcheng Xiang - Graduate Student WVU, Nick Wu research group. Authors also acknowledge the Department of Chemical Engineering/ WVU, WVNano and the National Science Foundation (#1033266 CBET) support. Alan Campbell and Cerasela Zoica Dinu acknowledge the National Science Foundation (#1063984 CMMI) support.

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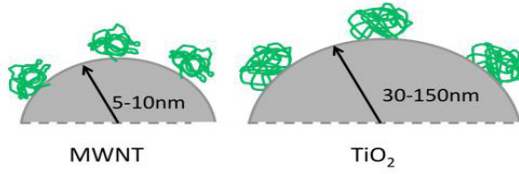
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Figures and Captions



Scheme 1: General mechanism of protein immobilization onto nanosupports. (a) Physical adsorption of enzymes onto nanosupports. (b) Covalent binding of enzymes onto nanosupports. (c) Carbon nanotube acid treatment.



Scheme 2: Representation of the effect of nanoparticle curvature on enzyme physical deformation and relative spacing (not to scale).

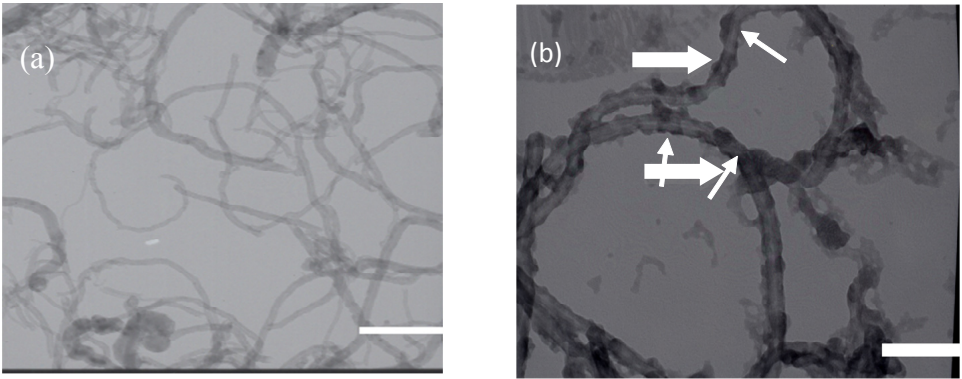


Figure 1: TEM of MWNTs. (a) Control MWNTs. (b) MWNTs-SBP based conjugates. The arrows point to enzyme immobilized onto the carbon nanosupports.

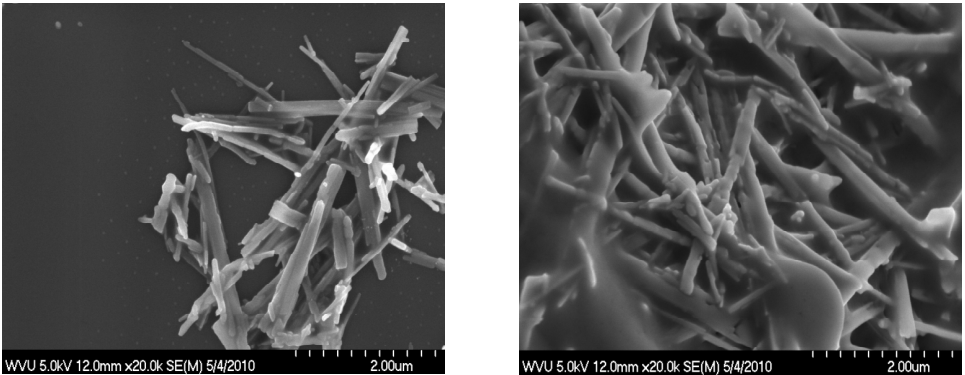


Figure 2: SEM of TiO₂ tubes. (a) Control TiO₂. (b) TiO₂-NT-SBP based conjugates.

EFFECTS OF FIXED-RATIO REQUIREMENTS ON DELAY DISCOUNTING IN RATS

Meagan Follett

Research on impulsive behavior is often designed to examine the choice between a smaller, more immediate reinforcer versus a larger, more delayed one (e.g., Anderson & Woolverton 2005; Diller, Saunders, & Anderson 2008; Logue 1988). When the delays to both the larger and smaller reinforcers are short, the larger reinforcer is usually chosen. As the delay to the larger reinforcer increases, choice for that reinforcer decreases and switches to choice for the smaller, more immediate reinforcer. This decrease in choice for the larger reinforcer as delay increases is known as delay discounting, as the value of the larger reinforcer is said to be discounted as delay to its presentation increases (Mazur 1987). Greater delay discounting has been correlated with substance abuse, gambling, and ADHD (Bickel, Odum, & Madden 1999; Perry & Carroll 2008; Dixon, Marley, & Jacobs 2003; Evenden 1999). Thus, much work has been aimed at assessing variables that affect delay-discounting rates. Relevant to the present study is the addition or subtraction of a constant delay to both the larger and smaller reinforcers.

Ainslie and Herrnstein (1981) demonstrated that when a constant delay is added to both the smaller, more immediate and the larger, more delayed reinforcer, choice that was initially maintained by the smaller reinforcer switches to the larger, more delayed reinforcer. This is often referred to as a preference reversal. In their study, Ainslie and Herrnstein used a discrete-trial procedure in which pigeons, with a single keypeck, chose between 2-s access and 4-s access to grain. In all sessions, the larger amount was always presented 4 s later than the smaller amount, while the delay to the smaller reinforcer was manipulated between 0.01-12 s. When the smaller reinforcer was delayed by 0.01 s, all subjects chose this option (impulsive choice) over the larger reinforcer delayed by 4.01 s. (self-controlled choice). As the delay to both the larger and smaller reinforcers increased, however, choice switched to the larger, more delayed reinforcer. When the delay to the smaller reinforcer was returned to 0.01 s, choice in four of the six subjects switched back to the smaller, more immediate reinforcer. The results of Ainslie and Herrnstein suggest that self-controlled choice in a delay-discounting procedure can be increased or decreased by adding or subtracting a constant delay to both alternatives, respectively.

In Ainslie and Herrnstein (1981), and in other delay-discounting studies (e.g., Anderson & Woolverton 2005; Cardinal, Robbins, & Everitt 2000; Charrier & Thiébot 1996; Diller, Saunders, & Anderson 2008; Evenden & Ryan 1996; Pitts & McKinney 2005), a fixed-ratio (FR) 1 schedule was used. The addition of an increased response requirement, with the additional time to complete it, would also increase the delay to reinforcement on both alternatives. Ainslie and Herrnstein (1981) found that an increase in the delay to both alternatives increased self-controlled choice, so it is possible that an increased response requirement could

have a similar effect. In fact, increased response requirement has been shown to increase self-controlled choice in pigeons.

Siegel & Rachlin (1995) suggested that "soft commitment" might be a method of increasing self-controlled choice. Soft commitment may be conceptualized as the pattern of behavior that develops once responding begins on one alternative. Responding will persist on that alternative to avoid the cost of switching, such as loss of reinforcement or an increased delay to reinforcement. In Siegel and Rachlin's study, pigeons were presented with red and green keys, which were alternated from side to side on each trial. For two subjects, the red key was associated with 2.5-s access to grain after a 0.05-s delay (impulsive choice) and the green key was associated with 4.5-s access to grain after a 3.5-s delay (self-controlled choice). These conditions were reversed for the other two subjects. To give exposure to contingencies prior to choice, 12 forced-choice trials in which only one key was lit and operative preceded all experimental trials. During baseline (Conditions 1, 3, 5, and 7), choice was between the smaller, more immediate and larger, more delayed reinforcers according to an FR 1 schedule. During Condition 2, an FR 31 schedule was in effect in which pecks on either key counted towards fulfillment of the ratio requirement. The key on which the 31st peck was made determined which outcome was obtained. When the response requirement was increased from 1 to 31, choice switched from the smaller, more immediate reinforcer to the larger, more delayed reinforcer. Condition 4 was a signaled FR 31 condition in which the final peck was signaled by both keys darkening and the houselight being illuminated for 1 s following the 30th peck. The response following the 1-s signal determined which outcome was delivered. Condition 6 was a fixed-interval (FI) 30-s schedule in which the first peck after 30 s had elapsed determined which outcome was presented. Greater self-controlled choice was observed during the FR 31 than the Signaled FR 31, FI 30 s, and all baseline (FR 1) conditions.

Siegel and Rachlin (1995) also found that although greater self-controlled choice was observed in the FR 31 condition, there was only an occasional switch from one alternative to the other in both the FR 31 and Sig FR 31 conditions. This suggests that once responding began on a particular key, it likely persisted throughout the ratio. Taken together, the results from Ainslie and Herrnstein (1981) and Siegel and Rachlin suggest that increasing the FR requirement will increase self-controlled choice (i.e., decrease delay discounting). This comparison suggests that just as the addition or subtraction of a constant delay can increase or decrease impulsive choice, the addition of a ratio requirement with the additional time to complete it can have the same effect.

The present study was designed to evaluate effects of an increasing FR requirement on self-controlled choice in a delay-discounting procedure with rats. It was expected that as the ratio requirement on both levers was increased, choice would switch from the smaller, more immediate reinforcer (impulsive choice) to the larger, more delayed reinforcer (self-controlled choice). Changes in delay discounting can be represented as changes in the area under the curve (AUC), which is the sum of the area under the normalized delay-discounting curve divided by the total possible area of the graph. Steeper discounting functions (i.e., increased impulsive choice) are associated with a smaller AUC. Shallower discounting functions (i.e., increased self-controlled choice) are associated with a larger AUC. To assess the increasing FR requirement, a within-session

delay-discounting procedure in which the FR requirement remained constant across blocks of trials was used.

One commonly used procedure to study delay discounting in non-human subjects was developed by Evenden and Ryan (1996). In this procedure, choice was between a smaller, more immediate reinforcer and a larger, more delayed reinforcer following a single response (FR 1). The delay to the larger reinforcer increased across blocks of trials within-session, while the delay to the smaller reinforcer remained constant at 0 s. Choice for the larger reinforcer was generally greater at the beginning of the session when the delay was short, and tended to decrease as the delay to larger reinforcer delivery increased. This procedure allows researchers to generate delay-discounting functions within a single session, which can provide a useful tool for studying effects of a number of variables (e.g., drugs) on delay discounting (e.g., Anderson & Woolverton 2005; Diller, Saunders, & Anderson 2008; Evenden & Ryan 1996; Pitts & McKinney 2005).

The addition of a ratio requirement to both keys in a self-control experiment with pigeons increased self-controlled choice (Siegel & Rachlin 1995). Prior to the current study, it was unknown if these results would generalize to a delay-discounting procedure with rats. The current study compared delay-discounting curves and AUC at one small (FR 1), medium ($\times/2$), and large (\times) FR value, where \times was the largest FR value that maintained lever pressing for each subject using a procedure similar to that of Evenden and Ryan (1996). This procedure extends the generality of previous findings in a novel context, and contributes to further assessment of factors that determine self-controlled choice.

Method

Subjects

Four adult male Sprague Dawley rats with experimental histories served as subjects. Two rats (S-1, S-2) had previous exposure to response acquisition, delay discounting, and ethanol self-administration tasks (Bruner 2010). Two rats (S-3, S-4) were used as subjects in a behavior principles class, and had previous exposure to basic reinforcement schedules. All subjects were housed in a colony room in the Life Sciences Building vivarium, where temperature and humidity were maintained at constant levels and a reverse 12-hour dark-light cycle was in effect (lights on at 6:00 p.m.). All sessions were conducted at approximately the same time seven days per week, during the dark phase of the dark-light cycle. Subjects were fed approximately 12 g of rat chow one half hour after each experimental session, resulting in approximately 22 hours food restriction before the start of each session. All procedures used were approved by the West Virginia University's Animal Care and Use Committee as part of protocol number 09-0824 to Dr. Karen Anderson.

Apparatus

Experimental sessions were conducted in four identical rat operant-conditioning chambers, each enclosed in a sound-attenuating cubicle with a ventilation fan

(Med Associates, VT). Each chamber contained a work area of 30.5 cm by 24.5 cm by 21.0 cm, a grid floor, and a 45-mg pellet dispenser with a pellet receptacle centered between two retractable response levers. The levers were 11.5 cm apart from each other and required a force of at least 0.25 N for a response to be recorded. The levers were 4.8 cm wide, protruded 1.9 cm into the chamber, and were elevated 8 cm from the grid floor. Two 28-V stimulus lights, 2.5 cm in diameter, were mounted approximately 7 cm above each lever. In addition, each chamber contained a 28-V houselight on the wall opposite of the pellet dispenser. Data were collected using a computer with MedPC-IV software (Med Associates, VT).

Procedure

Baseline procedure

All subjects had previous experience in experiments, and therefore lever-press training was not necessary. Sessions began with a 10-min blackout period followed by the illumination of the houselight and the start of the first trial. Each session consisted of 5 blocks of 8 trials. There were two types of trials, forced- and free-choice trials, each starting every 100 s. The first two trials in each block were forced-choice trials with one, randomly determined, lever extended into the chamber, and the cue light directly above it illuminated. A lever press (FR 1) on the extended lever resulted in that lever being retracted into the chamber, the cue light darkening, and the consequence programmed for responses on that lever being delivered. Delivery of the programmed consequence was followed by a blackout during which all lights were extinguished until the start of the next trial. For the other forced-choice trial, the other lever was extended into the chamber, the cue light above it was illuminated, and the other outcome was available. The forced-choice trials ensured exposure to both sets of contingencies prior to the beginning of free-choice trials. Two subjects (S-2, S-4) received one food pellet for pressing the right lever and three food pellets for pressing the left lever. These contingencies were reversed for the other two subjects (S-1, S-3).

After exposure to both sets of contingencies in the forced-choice trials, the following six trials in each block were free-choice trials. During these trials, both levers were extended and both cue lights were illuminated. A press on either lever (FR 1) resulted in both levers being retracted, both cue lights darkening, and the same programmed consequence as in forced-choice trials being delivered. If a lever press was not emitted within 30 s of the trial onset in both forced and free-choice trials, the levers were retracted, the cue lights darkened, and the trial was recorded as an omission.

To establish a baseline, food pellets (1 or 3) were delivered immediately following left and right lever presses, i.e., 0-s delays to both alternatives. This phase remained in effect until the 3-pellet alternative was chosen on at least 80% of the trials across all blocks. Following this condition, the delay to the larger reinforcer (3 food pellets) was increased across blocks of trials within each session while the delay to the smaller reinforcer remained 0 s. Delay series were individually determined for all subjects. S-1 and S-2 had previous exposure to a delay-discounting task, and previously determined delay series were used. S-3 and S-4 began re-

sponding on an 8 s delay series, which consisted of a 0-s delay in the first block and delays of 1, 2, 4, and 8 s in the following blocks. The 8-s delay series remained in effect until choice for the larger reinforcer in the free-choice trials of the 0-s block was at least 80%. The delays were then increased to 0, 2, 4, 8, and 16 s within session across blocks of trials. After the 16-s delay series, delays were increased or decreased as necessary for each subject to obtain intermediate delay discounting curves with no floor or ceiling effects. Floor and ceiling effects were identified by exclusive choice for the smaller or larger reinforcer, respectively. Delay series for all subjects are presented in the Table. The FR 1 condition remained in effect until choice was stable, which was defined as a minimum of 10 sessions and 80% or greater choice for the 3-pellet alternative in the first block of free-choice trials, less than 20% variation in total larger-reinforcer choice summed across all blocks, and no visibly increasing or decreasing trends in any of the blocks across the last five sessions.

FR procedure

Delay-discounting curves and AUC were compared at three FR values: small (FR 1), medium ($x/2$), and large (x), where x was the largest FR value that maintained lever pressing for each subject. Orders of conditions for all subjects are presented in the Table. The delay to the larger reinforcer increased within-session across all conditions. Once choice was stable under the FR 1 condition, the response requirement on both levers was increased to FR 2, FR 3, FR 5, FR 8, and FR 10, after which the response requirement increased by increments of five. Each response requirement was in effect for 3 sessions in which the number of free-choice omissions was less than 6. The required number of responses, specified by the FR contingency, had to be made on the same lever, but did not have to be consecutive. For example, in the FR 5 condition, 2 lever presses could occur on the left lever, followed by 2 lever presses on the right lever and another 3 lever presses on the left lever, which would complete the ratio requirement on the left lever, and the outcome associated with that lever would be presented. The response requirement was increased every 3 days until a value was reached at which choice was omitted in 6 or more free-choice trials within one session, or until choice was exclusive for the larger reinforcer. If more than 6 free-choice omissions occurred, the value previous to this maximum value was used as the FR in the large FR condition. The value that was one half of the large FR value was used as the FR value for the intermediate

FR condition

For 3 of the rats (S-2 and S-4), the large FR condition remained in effect until choice was stable, after which the FR requirement was decreased to the small (FR 1) value until choice was stable. Following stable choice in the small FR condition, the FR requirement was increased to the intermediate FR value, and the intermediate FR condition remained in effect until choice was stable. For one rat (S-3) the large FR condition remained in effect until choice was stable, after which the FR requirement was decreased to the small (FR 1) value until choice was stable. Following

stable choice in the small FR condition, the FR requirement was increased to the large FR value. For 1 rat (S-1), the large FR condition remained in effect until choice was stable, after which the response requirement was decreased to the intermediate FR value until choice was stable. Following stable choice in the intermediate FR condition, the response requirement was decreased to the small (FR 1) condition. The order of conditions for all subjects is presented in the Table.

The session immediately following stability at the small, intermediate, and large FR was a probe session in which all delays were 0 s. The purpose of this manipulation was to assess sensitivity to reinforcer amount and delay. If the larger (3-pellet) alternative was not chosen at least 80% of the time during the free-choice trials in each block, the probe session was repeated the next day until the criterion was met. The current response requirement remained in effect on probe days. For example, in a probe session following the FR $x=50$ condition, all delays would be 0 s, and the response requirement would remain at an FR 50.

Data Analysis

All data used were taken from the free-choice trials across the last 5 stable sessions of each condition. The main dependent measure was percent larger-reinforcer choice across each block in the various conditions. Percent larger-reinforcer choice for each block of trials was calculated by dividing the total number of larger-reinforcer choices by the total number of choices for both alternatives in each trial. Run rate was calculated by dividing the total number of responses in a single trial by the time from the first lever press on either lever to the completion of the ratio for each block of trials. Latency to the first response was calculated for each block of trials across the last 5 sessions of each condition. The number and order of presses on each lever was recorded to assess response patterns and switching.

AUC was calculated for all conditions according to the formula provided by Meyerson, Green, and Warusawitharana (2001). The AUC was calculated by first normalizing the delay plotted along the x-axis (0 to 1). Percent larger-reinforcer choice was plotted along the y-axis. Vertical lines were then drawn from each data point to the x-axis, creating a series of trapezoids. The sum of the area of these trapezoids was divided by the total possible area of the graph resulting in the total area under the discounting curve. Steeper discounting functions (i.e., increased impulsive choice) are associated with a smaller AUC. Shallower discounting functions (i.e., increased self-controlled choice) are associated with a larger AUC.

Results

Figure 1 shows percent choice for the larger reinforcer from the last five sessions of the small (FR 1), intermediate (FR $x/2$), and large (FR x) FR conditions for each subject at their respective terminal delay series. For all rats, regardless of terminal delay series, choice for the larger reinforcer decreased as delay to that reinforcer increased in the small (FR 1) condition. In general, steeper delay-discounting functions were obtained at the small FR requirement (FR 1), intermediate delay-discounting functions were obtained at the intermediate FR requirement (FR $x/2$), and

shallower delay-discounting functions were obtained at the large FR requirement (FR x). These findings are also indicated by differences in AUC across each FR condition, as shown in the Table. For S-1, discounting did not return to its original rate upon replication of the FR 1 condition. It was postulated that this subject developed a lever bias, and the order of conditions was subsequently changed for all other subjects such that an FR 1 condition was conducted after the FR x and FR $x/2$ conditions.

Figure 2 shows the latency to the first response from the last five sessions of the small (FR 1), intermediate ($x/2$), and large (x) conditions for each subject. As delay to the larger reinforcer increased, latency to the first response generally increased. This effect was more pronounced at the intermediate and large FR requirements. Relative to the small FR condition, latency to the first response during the intermediate and large condition was generally longer across all blocks. Individual subject data are presented in the Table.

Figure 3 shows the mean run rate from the last 5 sessions of the intermediate (FR $x/2$) and large (FR x) conditions for each subject. Run rates (responses per minute) from the first response to the completion of the FR requirement were similar across all delay blocks within each condition. Individual subject data are presented in the Table. For S-1, S-2 and S-4, higher run rates were obtained at the intermediate FR requirement compared to the large FR requirement. Run rates were calculated from the first response on either lever, as switching between levers rarely occurred. In general, once responding began on an alternative, it persisted on that alternative throughout the ratio.

Discussion

During the baseline (FR 1) condition, delay discounting was observed such that choice for the larger reinforcer decreased as the delay to its presentation increased regardless of delay series. Consistent with previous research (Siegel & Rachlin 1995), preference reversed from the smaller, more immediate reinforcer to the larger, more delayed reinforcer as the FR requirement increased across sessions. These findings suggest that manipulating response requirement within this procedure can increase self-controlled choice by increasing the work necessary to produce the larger outcome. It is unclear, however, whether the addition of an FR requirement, the additional time to complete the FR requirement, or both controlled choice.

Run rates (responses per minute) at both the intermediate and large FR requirements were similar across blocks of trials for all subjects. Switching between alternatives generally did not occur; once responding began on one alternative, it tended to persist on that alternative throughout the ratio, a finding consistent with Siegel and Rachlin (1995). For this reason, responses towards the fulfillment of the ratio requirement may be functioning as a single response unit. The emission of responses towards the fulfillment of the requirement as a single unit may provide one explanation as to why relatively high run rates were obtained for all subjects. The relatively high run rates obtained may have also been due to procedural factors, such as the limited hold, which required that all responses be made within 30 s of trial onset. Thus the requirement for reinforcement may have shaped increased run rates as slow rates may have resulted in missed reinforcement.

Siegel and Rachlin (1995) used an FR 31 as the large FR requirement for all subjects. In the current study, the large FR requirement was defined as the highest value that would maintain responding, or the value at which choice was exclusive for the larger reinforcer. The large FR requirement differed for all subjects. The current study extended the generality of Siegel and Rachlin's finding with a single FR requirement. Functionally determining a large and intermediate FR requirement for each subject allowed for a parametric analysis, which gives strength to the functional relation between FR requirements and larger-reinforcer choice.

The present study was the first to report effects of FR requirements on delay discounting in rats using a discrete-trial procedure similar to those commonly used (e.g., Evenden and Ryan 1996; Anderson & Woolverton 2005; Diller, Saunders, & Anderson 2008). Delay-discounting curves were examined at one small (FR 1), intermediate (FR $x/2$), and large (FR x) value, where x was the largest FR value that maintained responding for each subject. Delay discounting systematically decreased as the FR requirement increased for all subjects. This raises the question and potential for future investigation of whether it is the work requirement itself or additional delay that is controlling choice. Future investigation of effects of psychostimulants such as d-amphetamine on self-controlled choice using a procedure similar to that used in the present study may further elucidate mixed findings that result from different baseline rates of discounting.

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Table

Subject, order of conditions, number of sessions, x value, delay series, mean AUC with standard error of the mean in parenthesis, latency to first response averaged across blocks, and run rate in responses per minute averaged across blocks for each subject from the last five sessions of each FR condition.

Subject	Order of Conditions	Number of Sessions	x value	Delay Series	AUC <i>M (SEM)</i>	Latency (s)	Run Rate (Resp/min)
S-1	FR 1	21	15	16	0.30 (0.02)	1.7	-/-
	FR x	11			0.90 (0.02)	3.0	210.2
	FR x/2	14			0.63 (0.05)	1.7	234.5
	FR 1	18			0.90 (0.02)	0.6	-/-
S-2	FR 1	50	50	16	0.49 (0.07)	0.9	-/-
	FR x	10			0.95 (0.02)	3.8	170.1
	FR 1	12			0.46 (0.04)	1.9	-/-
	FR x/2	14			0.74 (0.02)	6.6	216.4
	FR 1	12			0.46 (0.03)	2.2	-/-
S-3	FR 1	22	40	64	0.37 (0.03)	0.5	-/-
	FR x	16			0.68 (0.08)	4.1	152.3
	FR 1	17			0.36 (0.02)	0.5	-/-
	FR x	10			0.72 (0.05)	4.4	163.8
	FR 1	10			0.30 (0.03)	0.4	-/-
S-4	FR 1	20	20	40	0.22 (0.02)	1.3	-/-
	FR x	10			0.81 (0.04)	2.2	72.3
	FR 1	22			0.27 (0.03)	1.0	-/-
	FR x/2	11			0.74 (0.03)	2.3	84.4
	FR 1	16			0.29 (0.03)	1.2	-/-

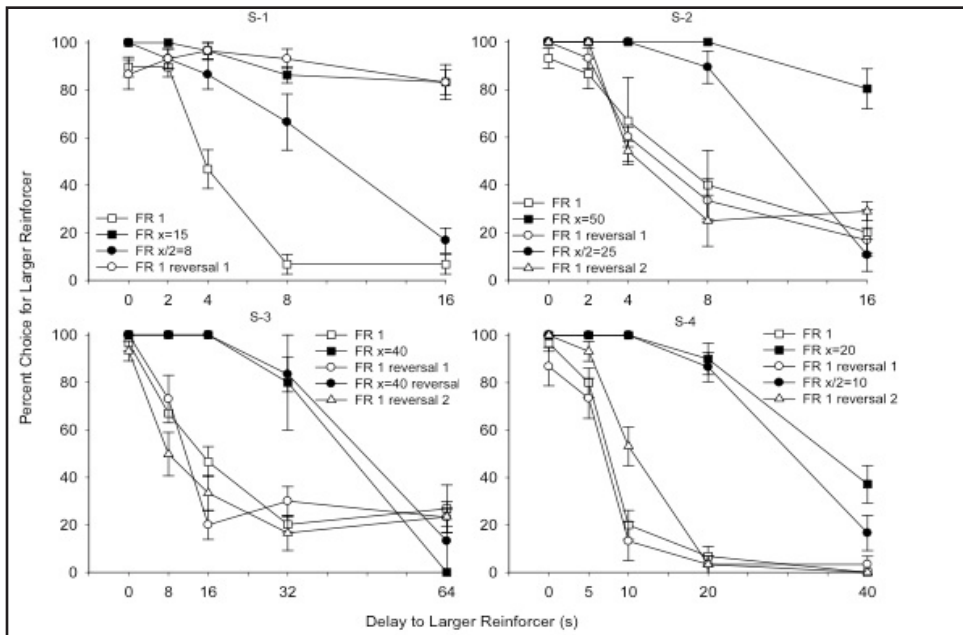


Figure 1. Mean percent larger-reinforcer choice across the last five sessions of each FR condition as a function of delay to the larger reinforcer for S-1 (top left panel), S-2 (top right panel), S-3 (bottom left panel), and S-4 (bottom right panel). Error bars represent standard error of the mean. Note that the scale for the x-axis differs among subjects.

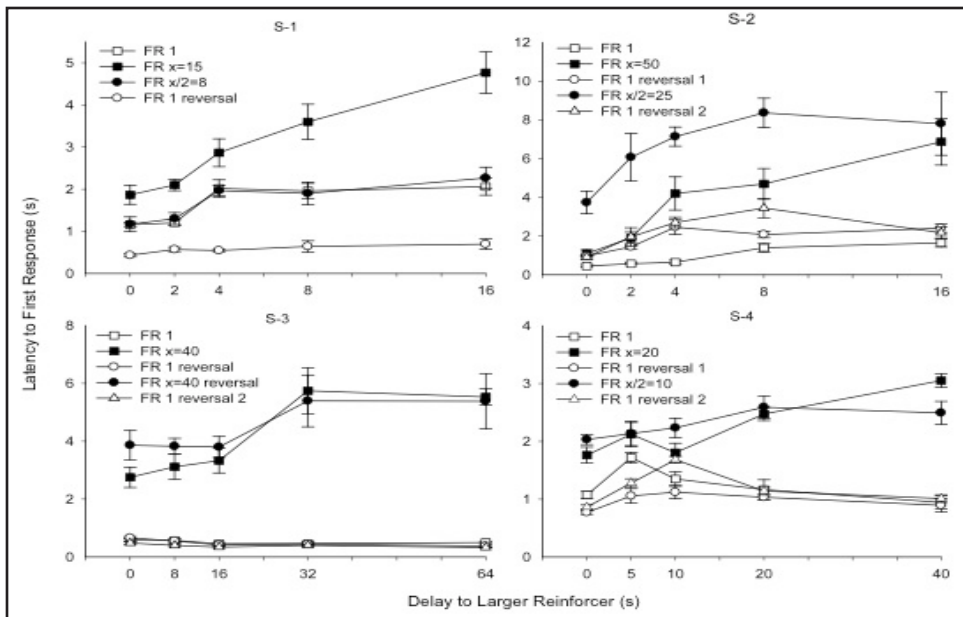


Figure 2. Mean latency to the first response during free-choice trials across the last five sessions of each FR condition as a function of delay to the larger reinforcer for S-1 (top left panel), S-2 (top right panel), S-3 (bottom left panel), and S-4 (bottom right panel). Error bars represent standard error of the mean. Note that the scale for the x- and y-axis differs among subjects.

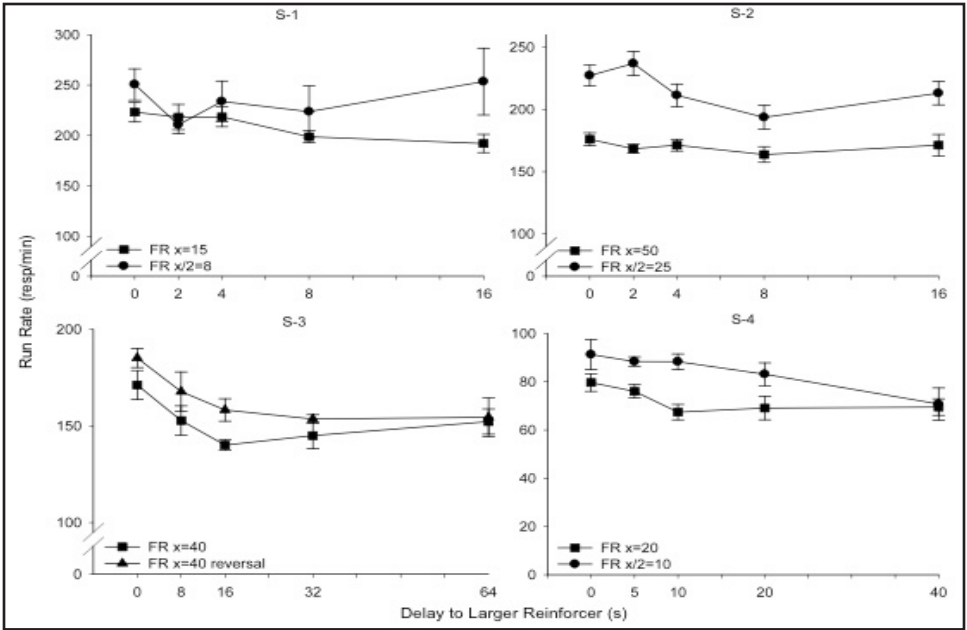


Figure 3. Mean run rate in responses per minute during free-choice trials across the last five sessions of the intermediate and large FR conditions as a function of delay to the larger reinforcer for S-1 (top left panel), S-2 (top right panel), S-3 (bottom left panel), and S-4 (top right panel). Error bars represent standard error of the mean. Note that the scale for the x- and y-axis differs among subjects.

CONSUMPTION OF DIFFERENT CALORIC SUGAR-SWEETENED SOLUTIONS ALTERS TISSUE FATTY ACID COMPOSITION AND LIPID METABOLISM IN YOUNG FEMALE SPRAGUE-DAWLEY RATS

Kaitlin Mock, Stephanie N. Altman, Joseph C. Gigliotti, Levi Berg and Janet C. Tou

Abstract

High carbohydrate intake has been reported to contribute to obesity by promoting *de novo* lipogenesis and metabolic disorders by altering tissue fatty acid composition. The type of caloric sweeteners added to beverages has changed with some sugars suggested to be more lipogenic. Therefore, the study objective was to determine the effect of consuming different types of caloric sugar-sweetened solutions on tissue fatty acid composition and risk of metabolic disorders. Growing female Sprague-Dawley rats were randomly assigned ($n=7-8$ rats/group) to drink water or water sweetened with 13% (w/v) glucose, sucrose, fructose or high fructose corn syrup 55 (HFCS-55). The rats were provided their assigned sugar-sweetened solution and purified diet *ad libitum*. After 8 weeks, fat pads and liver were dissected and tissue fatty acid composition was determined by gas chromatography. Serum cholesterol, triglyceride (TG), lipoprotein profile, and liver function were determined by enzymatic colorimetric assays. The type of sugar appeared to have different effects on fatty acid composition and dyslipidemia. Rats drinking HFCS-55 solution had greater *de novo* lipogenesis indicated by higher ($P=0.003$) palmitoleic acid and lower ($P=0.03$) linoleic acid in the liver compared to rats drinking water. In the adipose tissue, linoleic acid and alpha-linolenic acid was lower ($P<0.05$) in rats drinking HFCS-55 solution compared to rats drinking water. Dyslipidemia in rats drinking HFCS-55 solution was indicated by increased hepatic lipid content, serum TG, and low density lipoprotein. This has important health implications since HFCS-55 has become the major caloric sweetener added to beverages.

Introduction

Consumption of caloric sweeteners has increased with the primary source of added sugars in the American diet being sugar-sweetened beverages (Block, 2004). The type of caloric sweeteners consumed has also changed. In the United States, high fructose corn syrup (HFCS) has replaced sucrose as the sugar added to beverages (Bray et al., 2004). Consumption of HFCS-55 has been suggested to lead to a higher fructose intake because HFCS-55 is comprised of 55% fructose and 42%

glucose as monosaccharides (White, 2008); whereas, sucrose is comprised of 50% fructose and glucose as a disaccharide. According to the third National Health Examination Survey (NHANES) 1999–2004, fructose consumption has increased steadily with the highest consumers being young adults and the main source of fructose being soft drinks (Marriott et al., 2009). According to Popkin and Neilsen (2003), added sweeteners in soft drinks make a significant contribution to the human diet providing 318 kcals or 16% of total caloric intake.

The increase in fructose intake is a health concern because animal and humans studies have reported fructose to be a more potent inducer of hepatic *de novo* lipogenesis than glucose (Chong et al., 2007; Parks et al., 2008; Koo et al., 2008). Hepatic metabolism of fructose involves entry of fructose into glycolysis via fructose-1-phosphate which bypasses the rate controlling step of glycolysis catalyzed by phosphofruktokinase. This allows fructose to provide an unregulated source of substrates for triglyceride (TG) synthesis (Havel, 2005). Fructose independent of insulin stimulates sterol receptor element binding protein 1c (SREBP 1c) which activates genes involved in *de novo* lipogenesis (Miyazaki et al., 2004). Since fructose does not stimulate insulin secretion and insulin signals the central nervous system to inhibit food intake (Elliot et al., 2002), fructose has also been suggested to contribute to weight gain by stimulating food consumption. In the present study, animals were provided free access to the liquid and solid diet to determine food regulation.

According to Schwarz et al. (1995), a high carbohydrate diet results in greater *de novo* lipogenesis than a high fat diet. TG synthesized from carbohydrates consists mainly of palmitic acid (16:0), palmitoleic (16:1n-7), and oleic acid (18:1n-9) (Segall et al., 1970). Hudgins (2000) reported that lean and obese adult subjects provided a very low fat (10%) and high-carbohydrate diet (75%) enriched with glucose, fructose or sucrose increased very low density lipoproteins (VLDLs) and palmitic acid (16:0) and decreased linoleic acid (18:2n-6). In turn, endogenously synthesized TGs transported in VLDLs to adipose tissue may contribute to weight gain and subsequent obesity.

Obesity is often accompanied by a cluster of metabolic abnormalities, which is collectively referred to as the metabolic syndrome. Metabolic syndrome is characterized by visceral obesity, hypertriglyceridemia, reduced high-density lipoprotein (HDL-C), raised fasting glucose levels, and elevated blood pressure (Potenza and Mechanick, 2009). In addition, metabolic syndrome is often accompanied by non-alcoholic fatty liver disease (NAFLD) (Alberti et al., 2009). NAFLD characterized by excessive lipid accumulation has been observed in rats consuming high fructose diets (Davail et al., 2005).

In a human study, subjects consuming beverages sweetened with fructose had increased *de novo* lipogenesis, visceral adiposity, dyslipidemia, and decreased insulin sensitivity (Stanhope et al., 2009). High carbohydrate intake has been reported to contribute to obesity by promoting *de novo* lipogenesis and metabolic disorders by altering tissue fatty acid composition. Iggman et al. (2010) reported that adipose tissue enriched with palmitic acid and depleted of essential fatty acids was associated with insulin resistance. In rats, long-term feeding of moderate amounts of fructose (15% of the diet by weight) impaired glucose tolerance while feeding high amounts of fructose (72% of the diet by weight) resulted in the development of diabetes mellitus (Blakely et al., 1981). Many animal studies reporting

adverse health effects have used doses of sweeteners that are not typically encountered in the human diet. Therefore, the objective of this study was to determine the effect of different caloric sugar-sweetened solutions provided at a dose typically added to soft drinks on tissue fatty acids composition and risk of metabolic abnormalities.

Materials and Methods

Animal and Diets

All animal procedures were approved by the Animal Care and Use Committee at West Virginia University and conducted in accordance with the guidelines set forth by the National Research Council for the Care and Use of Laboratory Animals (1996). Immature (age 28 days) female Sprague-Dawley rats (n=36) were purchased from Taconic Farms (Rockville, MD). The rats were individually housed in metabolic cages to measure liquid and food intake. Rats were kept in a room at a constant temperature of 21°C with a 12 h light/dark cycle. During a 7 d acclimation period, animals were given *ad libitum* access to distilled water and purified AIN-93G diet (Harlan Teklad; Indianapolis, IN).

Following acclimation, animals were randomly assigned to one of five treatments (n=7-8 rats/group). Treatment groups consisted of either distilled water with no caloric sweetener added or distilled water sweetened with glucose, sucrose, fructose or HFCS-55. The different caloric sweeteners were added at the level of 13% (w/v) which is the dose reported in soft drinks (Jurgens et al, 2005). The rats were given *ad libitum* access to their assigned liquid solution and to purified AIN-93G diet throughout the 8 week study to assess food selection and regulation. The purified AIN-93G diet was used because it meets the nutritional requirements for growing rats as defined by the Nutritional Research Council (1995) and has a defined sucrose content and lipid source. The diet ingredients and fatty acid composition of the AIN-93G is shown in Table 1. Water and caloric sugar-sweetened solutions were measured and replaced daily. Food intake and body weights were measured weekly.

Organ Fatty Acid Composition

At the end of the 8 week feeding study, rats were fasted overnight then euthanized by CO₂ inhalation. The liver and the major fat pads (gonadal and retroperitoneal) were excised, weighed, and immediately frozen in liquid nitrogen. Tissues were kept stored at -80°C until analyzed. Lipids were extracted from tissue samples according to the method by Bligh and Dyer (1959) and all samples were measured in duplicates. Briefly, samples were weighed and nonadecenoic (19:1) added as an internal standard, and samples were homogenized in a Tris/EDTA buffer (pH 7.4) and a chloroform:methanol:acetic acid (2:1:0.15 v/v/v) solution was added to the samples. Samples were centrifuged at 900 g for 10 min at 10°C and the bottom chloroform layer was then filtered through 1-phase separation filters. The extracted lipid was dried under nitrogen gas. Liver lipid content was calculated as lipid (g)/tissue wt (g) x 100.

Extracted lipid samples were transmethylated according to the method by Fritsche and Johnston (1990). Briefly, fatty acid methyl esters were generated by adding 4% H₂SO₄ in methanol to the dried lipid samples and incubated at 90°C for 60 min. Samples were cooled to room temperature and 3 mL of distilled water was added. Chloroform was added to the methylated sample, centrifuged at 900 g for 10 min at 10°C, and the bottom layer collected. Methylated samples were dried under nitrogen gas and resuspended in iso-octane to a concentration of 5 mg methylated lipid sample/mL of iso-octane.

The methylated lipid samples were analyzed by gas chromatography (CP-3800, Varian Inc, Walnut Creek, CA) using an initial temperature of 140°C held for 5 min and then increased 1°C per min to a final temperature of 220°C. A wall-coated open tubular fused silica capillary column (Varian Inc, Walnut Creek, CA) was used to separate fatty acid methyl esters with CP-Sil 88 as the stationary phase. Nitrogen was used as the carrier gas, and total separation time was 56 min. Quantitative 37 component fatty acid methyl esters Sigma Mix (Supelco, Bellefonte, PA) was used to identify and quantify fatty acids. Fatty acids were identified using retention time and peak area counts.

Serum Clinical Measurements

Trunk blood was collected and centrifuged at 1,500 g for 10 min at 4°C and the serum collected and kept frozen at -80°C until analyzed. Fasting serum cholesterol, TG, VLDL, low density lipoprotein (LDL-C), and HDL-C were determined by lipid test rotor enzymatic colorimetric assays and measured using a Hemagen Analyst automated spectrophotometer (Hemagen Diagnostics Inc., Columbia, MD). Serum lipid and lipoprotein values reported in this study were within the range reported for rats (DeMoura et al., 2008).

Liver function was assessed by measuring serum alanine transferase (ALT), Gamma-glutamyl transferase (GGT), bilirubin, and albumin. Serum liver function biomarkers were determined by Vet 16 veterinary test rotor enzymatic colorimetric assays measured using a Hemagen Analyst automated spectrophotometer. Serum liver function values reported in this study were within the range reported for rats.

Statistical Analysis

One-way ANOVA was used to determine differences among the treatment groups. Post-hoc multiple comparison tests were performed using Tukey's test with treatment differences considered significant at $P < 0.05$. All statistical analyses were performed using the SigmaStat 3.1 statistical software program (Systat Software Inc, San Jose, CA).

Results

Animal Caloric and Macronutrient Intake

Rats provided glucose solution had the highest liquid intake among the treatment groups. Rats drinking sucrose solution had significantly higher liquid intake than rats drinking fructose solution. Food intake was lower ($P=0.009$) in rats drinking glucose, sucrose or HFCS-55 solution compared to rats drinking water. Additionally, food intake was significantly reduced in rats drinking glucose solution compared to rats drinking HFCS-55 or fructose solution. Food intake was also reduced in rats drinking sucrose compared to fructose solution. Differences in food and liquid consumption resulted in differences in total caloric intake. Rats drinking glucose solution had greater ($P=0.03$) total caloric intake compared to rats drinking HFCS-55 solution or water (Table 2).

Total sugar intake was highest in rats drinking glucose solution. Rats provided sucrose solution had significantly greater total sugar intake compared to rats provided fructose solution. Total lipid intake was lower ($P=0.009$) in rats drinking glucose, sucrose or HFCS-55 solution compared to rats drinking water. Additionally, total lipid intake was significantly lower in rats provided glucose compared to rats drinking HFCS-55 or fructose solution. Lipid intake was also significantly lower in rats drinking sucrose than rats drinking fructose solution (Table 2).

Animal Body and Organ Weights

There were no significant differences in final body weights, retroperitoneal or gonadal fat pad weights among the treatment groups. Absolute liver weight was higher ($P=0.03$) in rats drinking HFCS-55 solution compared to rats drinking water, but not when expressed as relative liver weight (Table 3).

Liver Fatty Acid Composition

The saturated fatty acid, myristic acid (14:0) was higher ($P=0.02$) in rats drinking HFCS-55 compared to rats drinking glucose solution. Hepatic palmitoleic acid (16:1n-7) was highest in rats drinking glucose solution. Rats drinking HFCS-55 solution had significantly greater hepatic palmitoleic acid compared to rats drinking water. Oleic acid (18:1n-9) was higher ($P=0.02$) in rats provided glucose solution compared to rats drinking fructose, sucrose solution or water. Additionally, hepatic oleic acid was significantly higher in rats drinking HFCS-55 solution compared to rats drinking fructose solution or water. Hepatic linoleic acid (18:2n-6) was lower ($P=0.03$) in rats drinking glucose or sucrose solution compared to rats drinking water. Only rats drinking glucose had decreased hepatic alpha-linolenic acid compared to rats drinking water (Table 4).

Adipose Tissue Fatty Acid Composition

In the gonadal fat pad, palmitoleic acid was higher ($P=0.03$) in rats drinking glucose solution compared to rats drinking water. Rats drinking glucose solution had the lowest linoleic acid among the treatment groups. Rats drinking HFCS-55 solution had significantly lower linoleic acid compared to rats drinking water. Alpha-linolenic acid and arachidonic acid (20:4n-6) were lowest in rats drinking glucose solution (Table 5).

In the retroperitoneal fat pad, palmitic acid (16:0) was higher ($P=0.003$) in rats provided glucose solution compared to rats drinking water, fructose or HFCS-55 solution. Fat pad palmitoleic acid was higher ($P=0.01$) in rats provided glucose solution compared to rats drinking fructose solution or water. Also, rats drinking sucrose had significantly higher palmitoleic acid compared to rats drinking water. Oleic acid was higher ($P=0.008$) in rats provided glucose solution compared to rats drinking solutions of fructose, HFCS-55 or water (Table 6). In the retroperitoneal fat pad, linoleic, alpha-linolenic, and arachidonic acid were significantly reduced in rats provided glucose or HFCS-55 solution compared to rats drinking water. Additionally, arachidonic acid was lower ($P=0.03$) in rats drinking glucose solution compared to rats drinking fructose solution (Table 6).

Serum Clinical Measurement

Liver lipid content was greater in rats drinking HFCS-55 solution ($P=0.005$) compared to rats drinking fructose solution. There were no significant differences in fasting serum glucose or insulin concentrations among the treatment groups. Rats drinking HFCS-55 solution had significantly higher serum TG concentration compared to rats drinking water. There was no significant difference in serum VLDL; however, rats drinking HFCS-55 solution had higher ($P=0.02$) serum LDL-C concentrations compared to rats drinking water. There were no significant differences in serum HDL-C or total cholesterol among the treatment groups. There were no differences in liver function indicated by no significant differences in serum ALT, GGT, bilirubin, and albumin concentration among rats drinking water or the different caloric sugar-sweetened solutions (Table 7).

Discussion

The results showed differences in tissue fatty acid composition and lipid metabolism among female rats drinking different caloric sugar-sweetened solutions. According to Segall et al. (1970), the most consistent effect of high carbohydrate induced *de novo* lipogenesis is an increase in palmitoleic acid and decrease in linoleic acid tissue content. In our study, rats provided HFCS-55, but not sucrose solution had increased hepatic *de novo* lipogenesis indicated by significantly higher liver palmitoleic acid compared to rats drinking water. In contrast, Fukuchi et al. (2004) reported that male Wistar King A rats provided a high (34%) sucrose liquid diet for 4 weeks increased hepatic palmitoleic acid compared to rats provided water. However, rats provided sucrose had greater sugar and total caloric

intake. In our study there were no significant differences in total calories, sugar or lipid intake between rats drinking HFCS-55 and sucrose solution. Based on our study results, HFCS-55 solution which provided slightly higher (55%) fructose as a monosaccharide appeared to be more lipogenic than fructose (50%) provided by sucrose as a disaccharide. Fructose and glucose consumed as monosaccharides rather than disaccharide may result in greater absorbability and the higher dietary fructose intake promotes hepatic *de novo* lipogenesis. In the liver, metabolism of fructose bypasses the major control point in glycolysis allowing fructose to serve as an unregulated source of precursors for *de novo* lipogenesis (Havel, 2005). Interestingly, in our study, rats provided HFCS-55, but not pure fructose solution had increased hepatic *de novo* lipogenesis. In a human study, healthy subjects administered equivalent amounts of pure fructose, glucose or HFCS-sweetened beverages resulted in similar increases in postprandial TGs (Stanhope et al., 2008). The results suggested that co-ingestion of glucose potentiates the lipogenic effect of fructose since HFCS contains approximately half the amount of pure glucose or fructose, yet produced similar lipid responses (Tappy and Le, 2009).

Another mechanism whereby dietary fructose has been suggested to contribute to weight gain is by stimulating energy intake (Elliot et al., 2002). Sugar consumption in liquid form has been reported to promote positive energy balance; whereas, comparable sugar in solid form resulted in dietary compensation (Mattes, 2006; DiMeglio and Mattes, 2000). In our study, rats provided caloric sweetened solutions *ad libitum* resulted in rats provided glucose solution drinking the most liquid and adjusted for increased calories obtained from liquid by reducing caloric intake from the solid diet. Lower ($P=0.009$) dietary lipid intake in rats drinking glucose solution resulted in significantly reduced hepatic essential fatty acid compared to rats drinking water. On the other hand, rats drinking glucose solution had significantly higher *de novo* lipogenesis indicated by significantly higher hepatic MUFAs, palmitoleic acid and oleic than rats drinking fructose solution. In contrast, studies in rats, mice, and humans have reported fructose consumption to be a more potent inducer of hepatic lipogenesis than glucose (Parks et al., 2008; Chong et al., 2007; Koo et al., 2008). In our study, higher hepatic MUFAs may be due to rat drinking glucose solution having the highest total sugar consumption due to their higher liquid intake. Our results demonstrated that sugar quantity consumed can over-ride the greater lipogenic effects of fructose.

Altered fatty acid composition in the liver may lead to fatty acid imbalances in the adipose tissues since adipose stores excess TGs. In the gonadal fat pad, essential fatty acids (linoleic acid and alpha-linolenic acid) were lowest in rats drinking glucose. Rats drinking glucose solution had the lowest lipid intake among the treatment groups. Additionally, arachidonic acid was lowest in rats drinking glucose solution. Arachidonic acid (20:4n-6) was not detectable in the purified AIN-93G diet and therefore, must be derived from the precursor linoleic acid (18:2n-6). The adipose tissue typically reflects dietary intake although the adipose tissue can perform *de novo* lipogenesis in response to changes in dietary intake. Rats drinking glucose solution had the highest sugar intake among the treatment groups and palmitoleic acid was higher ($P=0.03$) in rats provided glucose solution compared to rats drinking water.

Fatty acid composition in the gonadal fat pad differed from the retroperitoneal fat pad. In the retroperitoneal fat pad, palmitoleic acid was higher ($P=0.01$)

in rats drinking glucose or sucrose solution compared to rats drinking water. Additionally, rats drinking glucose showed significantly higher palmitic and oleic acid compared to rats drinking water, fructose or HFCS-55 solution. TG synthesized from carbohydrates consists mainly of palmitic acid, palmitoleic, and oleic acid (Segall et al., 1970). Similar to the gonadal fat pad, essential fatty acids and arachidonic acid were significantly lower in the retroperitoneal fat pad of rats drinking glucose solution compared to rats drinking water. Lipid intake was also reduced ($P=0.009$) in rats drinking sucrose or HFCS-55 solution compared to rats drinking water. However, decreased linoleic acid and alpha-linolenic acid occurred in the fat pads of rats drinking HFCS-55, but not sucrose solution. This may be due to fatty acid accumulation in the liver and decreased transport to the adipose tissue. Fatty acid accumulation in the liver was indicated by reduced hepatic linoleic acid in rats drinking sucrose or glucose solution, but not HFCS-55 solution. Additionally, liver lipid content was higher ($P=0.005$) in rats drinking HFCS-55 solution.

In humans, fat distribution (visceral fat) is an accepted risk factor for metabolic syndrome. However, the effect of different fat pads on metabolism in rats is uncertain. According to Fabbrini et al. (2009), the degree of intra-hepatic lipid is a better predictor of metabolic abnormalities than adipose tissue. Excessive *de novo* lipogenesis results in intra-hepatic lipid accumulation that may lead to non-alcoholic fatty liver disease (NAFLD) (Lim et al., 2010). Patients with NAFLD are more likely to have dyslipidemia (Le and Bortolotti, 2009). The earliest metabolic perturbation of increased *de novo* lipogenesis is postprandial hypertriglyceridemia (Teff et al., 2009). In our study, serum TG concentration was higher ($P=0.02$) in rats drinking HFCS-55 solution compared to rats drinking water. TG synthesized by the liver may be transported into the circulation as TG-rich VLDL. In turn, VLDL can be converted to LDL-C. In our study, female rats drinking HFCS-55 solution had no effect on fasting serum VLDL, but increased ($P=0.02$) serum LDL-C compared to rats drinking water.

Key substrates for TG synthesis are MUFAs (Flowers and Ntambi, 2010). Hepatic MUFAs, palmitoleic acid and oleic acid were significantly increased in rats drinking HFCS-55, but not sucrose solution compared to rats drinking water. In humans, increased plasma palmitoleic acid has been independently associated with hypertriglyceridemia (Paillard et al., 2007). In our study, rats drinking glucose solution had increased hepatic MUFAs, palmitoleic acid and oleic acid, but no effect on serum TGs or LDL-C. Unlike HFCS-55, hepatic linoleic acid was significantly lower in rats provided glucose or sucrose compared to rats drinking water. *De novo* lipogenesis that exceeds the oxidative capacity or needs of the liver results in excessive formation of malonyl-CoA which in turn, inhibits β -oxidation (Lim et al., 2009). We speculated that the combination of *de novo* lipogenesis and impaired β -oxidation resulted in the intra-hepatic lipid accumulation and dyslipidemia observed in rats drinking HFCS-55, but not glucose or sucrose solution. However, mechanistic studies are required to specifically address this observation. Also, of interest was the observation of altered liver total lipid content, fatty acid composition, and dyslipidemia in rats drinking HFCS-55 solution in the absence of adiposity. In a human study, sugar-sweetened beverage consumption was associated with intra-hepatic lipid accumulation independent of the degree of obesity (Assay et al., 2008).

Lipid accumulation in the liver has also been suggested to promote damage due to the oxidative susceptibility of fatty acids (Lim et al., 2010). In a human

study, healthy subjects administered a diet with 25% total energy as sucrose resulted in a rise in hepatic ALT and GGT concentrations (Porikos and Van Itallie, 1983). In our study, there was no effect on liver function indicated by no significant increase in serum ALT, GGT, bilirubin or albumin among rats drinking different caloric sugar-sweetened solutions.

Insulin resistance is another disorder characterizing the metabolic syndrome. Iggman et al. (2010) reported that adipose tissue enriched with palmitic acid and depleted of essential fatty acids was associated with insulin resistance. In our animal study, rats drinking glucose solution had significantly higher palmitic acid accompanied by depletion of essential fatty acids in the fat pads. However, there was no difference in fasting serum insulin or glucose among any of the treatment groups. In contrast, Fukuchi et al. (2004) reported increased plasma glucose, insulin, and adiposity after 20 weeks of sucrose loading of male rats. Our study duration was eight weeks and there were no significant increase in adiposity among the treatment groups. Also, several studies have suggested female rats are protected against fructose and sucrose induced changes in metabolism (Galipeau et al., 2002; Horton et al., 1997). However, a recent study reported that Sprague-Dawley female rats provided 10% w/v fructose solution for 14 d had higher incidence of glucose intolerance than their male counterparts. The authors suggested that this was due to the stronger induction of fructokinase in the liver of fructose-fed female rats than male rats (Vila et al., 2010).

In summary, among the different types of caloric sweeteners investigated, HFCS-55 consumption increased hepatic MUFAs and caused dyslipidemia. Although both HFCS-55 and sucrose provide glucose and fructose, only HFCS-55 increased hepatic palmitoleic acid. There were no significant differences in total calories, sugar or lipid intake between rats drinking HFCS-55 and sucrose, except for a slightly higher amount of fructose as monosaccharides. Based on the study, the type of sugar does appear to have an important effect on liver fatty acid composition and lipid metabolism. The relevance of the animal study findings to humans is important to investigate due to continuing controversy regarding the health implications of replacing sucrose with HFCS-55 in beverages and the role of caloric sweeteners in obesity and metabolic syndrome.

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Tables

Table 1. Diet nutrient and fatty acid composition.

Ingredients	g/kg diet
Corn Starch	397.5
Dextrinized cornstarch	132.0
Sucrose	100.0
Fiber	50.0
Casein	200.0
L-Cystine	3.0
Vitamin Mix**	10.0
Mineral Mix**	35.0
Choline bitartrate	2.5
Tert-butylhydroquinone	0.014
Soybean oil	70.0
Fatty acids	mg/g diet
Saturated fatty acids	
Myristic acid, 14:0	ND
Palmitic acid, 16:0	32.7 ± 0.8
Stearic acid, 18:0	7.3 ± 1.1
Monounsaturated fatty acids	
Palmitoleic acid, 16:1n-7	ND
Oleic acid, 18:1n-9	211.1 ± 3.5
Polyunsaturated fatty acids	
Linoleic acid, 18:2n-6	234.3 ± 3.5
Alpha-linolenic acid, 18:3n-3	28.5 ± 0.4
Arachidonic acid, 20:4n-6	ND
Eicosapentaenoic acid, 20:5n-3	0
Docosahexaenoic acid, 22:6n-3	0
*Result ² are expressed as Mean ± SEM of n=3 samples	8.2 ± 0.2

**Based on the AIN-93G vitamin and mineral mixes (Reeves, 1997)

Abbreviation is ND, not detected.

Table 2. The effect of feeding different caloric sugar-sweetened so
growing rats.

Measurement	Water	Gl
Total liquid intake (mL)	1927±205 ^{bc}	492
Total food intake (g)	982±30 ^a	61
Total caloric intake (kcal)	3731±113 ^b	467
Total sugar intake (g)	349±27 ^{bc}	70
Total lipid intake (g)	687±21 ^a	429

* Values are expressed as the mean ± SEM of n=7-8 rats/group. D
the same rows indicate significant differences at $P < 0.05$ by one-w
Abbreviation is HFCS-55, high fructose corn syrup 55.

solution on caloric and macronutrient intake by

Treatments*				
Sucrose	Fructose	Sucrose	HFCS-55	P-value
1844±440 ^a	1553±254 ^c	3144±322 ^b	2762±306 ^{bc}	0.01
133±35 ^d	899±19 ^{ab}	698±39 ^{cd}	784±44 ^{bc}	0.009
44±165 ^a	4223±132 ^{ab}	4184±129 ^{ab}	4086±182 ^b	0.03
22±55 ^a	292±33 ^c	479±38 ^b	437±39 ^{bc}	0.02
9±24 ^d	629±16 ^{ab}	488±27 ^{cd}	549±31 ^{bc}	0.009

different superscript letters a, b, c, d within
 day ANOVA followed by Tukey's test.

Table 3. Consumption of different caloric-sweetened solutions by

Measurement	Water	
Final body weight (g)	256±6	25
Absolute retroperitoneal adipose weight (g)	3.87±0.38	3.
Relative retroperitoneal adipose weight (mg/g bwt)	15.1±1.5	14
Absolute gonadal adipose weight (g)	7.85±0.75	8.
Relative gonadal adipose weight (mg/g bwt)	30.8±3.1	33
Absolute liver weight (g)	6.46±0.27 ^b	6.
Relative liver weight (mg/g bwt)	25.1±1.0	27

*Values are expressed as the mean ± SEM of n=7-8 rats/group. Diff significant differences at $P<0.05$ by one-way ANOVA followed by 55.

growing female rats on body weight, fat mass, and organ weights.

Treatments*				
Glucose	Fructose	Sucrose	HFCS-55	P-value
54±4	276±7	276±3	276±8	0.09
71±0.38	3.64±0.32	3.90±0.26	4.87±1.2	0.57
4.6±1.4	13.3±1.3	14.1±0.9	17.2±3.5	0.65
47±0.90	8.30±0.67	10.43±0.47	11.57±2.4	0.15
3.3±3.3	30.1±2.6	37.9±1.8	40.9±7.2	0.25
94±0.36 ^{ab}	7.37±0.36 ^{ab}	7.31±0.24 ^{ab}	7.95±0.25 ^a	0.03
7.3±1.4	26.6±0.8	26.5±0.7	28.9±1.3	0.21

Different superscript letters a, b within the same rows indicate significant differences as determined by Tukey's test. Abbreviation is HFCS-55, high fructose corn syrup-

Table 4. Consumption of different caloric-sweetened solutions by

Fatty acids (%)	Water	Trea Fruc
Saturated fatty acids		
Myristic acid, 14:0	0.70 \pm 0.15	0.62 \pm
Palmitic acid, 16:0	23.4 \pm 3.0	20.1 \pm
Stearic acid, 18:0	13.8 \pm 1.3	12.0 \pm
Monounsaturated fatty acids		
Palmitoleic acid, 16:1n-7	1.9 \pm 0.4 ^b	2.6 \pm
Oleic acid, 18:1n-9	16.2 \pm 1.9 ^b	17.3 \pm
Polyunsaturated fatty acids		
Linoleic acid, 18:2n-6	26.2 \pm 3.0 ^a	15.6 \pm
Alpha-linolenic acid, 18:3n-3	1.9 \pm 0.3	1.0 \pm
Arachidonic acid, 20:4n-6	11.1 \pm 1.0	9.5 \pm
Eicosapentaenoic acid, 20:5n-3	ND	ND
Docosahexaenoic acid, 22:6n-3	ND	ND

*Values are expressed as the mean \pm SEM of n=7-8 rats/group. within the same rows indicate significant differences at $P < 0.05$. Abbreviations are HFCS-55, high fructose corn syrup 55; ND, ND.

growing female rats on liver fatty acid composition.

Diets ^a	Sucrose	HFCS-55	<i>P</i> -value
0.12	0.80 ±0.16	1.1 ±0.26	0.02
3.2	26.0 ±3.1	32.5 ±4.5	0.15
18	11.6 ±1.6	12.0 ±1.5	0.33
0.5 ^{ab}	4.4 ±0.7 ^{ab}	5.8 ±0.8 ^a	0.003
2.9 ^b	22.9 ±2.9 ^{ab}	35.9 ±4.0 ^a	0.02
3.1 ^{ab}	13.3 ±2.3 ^b	17.5 ±4.2 ^{ab}	0.03
0.2	0.9 ±0.3	1.1 ±0.3	0.006
2	10.0 ±1.7	10.0 ±1.1	0.87
	ND	ND	
	ND	ND	

^a Different superscript letters a, b, c
^b by one-way ANOVA followed by Tukey's test.
 ND not detectable.

Table 5. Consumption of different caloric-sweetened solutions by

Fatty Acids (%)	Water	Glucose
Saturated fatty acids		
Myristic acid, 14:0	4.6 ±0.4	3.7 ±0.6
Palmitic acid, 16:0	79.6 ±4.3	89.7 ±10.4
Stearic acid, 18:0	9.9 ±0.5	6.5 ±1.4
Monounsaturated fatty acids		
Palmitoleic acid, 16:1n-7	49.1 ±3.8 ^b	89.1 ±9.9 ^a
Oleic acid, 18:1n-9	392.1 ±16.8	429.2 ±51.1
Polyunsaturated fatty acids		
Linoleic acid, 18:2n-6	220.1 ±17.8 ^a	52.3 ±8.7 ^c
Alpha-linolenic acid, 18:3n-3	20.8 ±2.3 ^a	3.5 ±0.7 ^b
Arachidonic acid, 20:4n-6	3.8 ±0.5 ^a	0.7 ±0.1 ^b
Eicosapentaenoic acid, 20:5n-3	ND	ND
Docosahexaenoic acid, 22:6n-3	ND	ND

*Values are expressed as the mean ± SEM of n=7-8 rats/group within the same rows indicate significant differences at $P < 0.05$. Abbreviations are HFCS-55, high fructose corn syrup 55; ND, ND

growing female rats on gonadal fat pad fatty acid composition.

Treatment*			
Fructose	Sucrose	HFCS-55	P-value
5.1±0.8	5.9±0.7	3.9±0.5	0.08
90.3±13.9	104.5±11.9	76.9±7.3	0.37
10.6±1.0	10.0±2.0	7.4±1.3	0.15
65.3±10.8 ^{ab}	73.7±10.9 ^{ab}	70.8±9.1 ^{ab}	0.03
457.1±70.3	526.5±62.5	385.6±30.8	0.31
175.8±18.1 ^{ab}	164.8±11.5 ^{ab}	147.9±22.1 ^b	0.03
16.2±1.9 ^a	14.0±1.9 ^a	14.8±2.4 ^a	0.003
3.0±0.3 ^a	3.1±0.3 ^a	2.7±0.6 ^a	0.006
ND	ND	ND	
ND	ND	ND	

ap. Different superscript letters a, b, c
 05 by one-way ANOVA followed by Tukey's test.
 D, not detectable.

Table 6. Consumption of different caloric-sweetened solutions by group

Fatty acid (%)	Water	Glucose
Saturated fatty acids		
Myristic acid, 14:0	3.0 \pm 0.4	3.6 \pm 0.6
Palmitic acid, 16:0	73.0 \pm 6.9 ^b	116.0 \pm 6.2 ^a
Stearic acid, 18:0	7.4 \pm 1.3	8.1 \pm 1.1
Monounsaturated fatty acids		
Palmitoleic acid, 16:1n-7	50.7 \pm 5.3 ^c	104.1 \pm 7.9 ^a
Oleic acid, 18:1n-9	339.0 \pm 47.9 ^b	571.4 \pm 33.1 ^a
Polyunsaturated fatty acids		
Linoleic acid, 18:2n-6	131.7 \pm 16.3 ^a	57.1 \pm 9.5 ^b
Alpha-linolenic acid, 18:3n-3	8.7 \pm 1.1 ^a	3.4 \pm 0.7 ^b
Arachidonic acid, 20:4n-6	1.5 \pm 0.2 ^a	0.4 \pm 0.2 ^c
Eicosapentaenoic acid, 20:5n-3	ND	ND
Docosahexaenoic acid, 22:6n-3	ND	ND

*Values are expressed as the mean \pm SEM of n=7-8 rats/group. Values within the same rows indicate significant differences at $P < 0.05$. Abbreviations are HFCS-55, high fructose corn syrup 55; HFCS-100, high fructose corn syrup 100.

following female rats on retroperitoneal fat pad fatty acid composition.

Treatment*			
Fructose	Sucrose	HFCS-55	<i>P</i> -value
2.5±0.4	3.9±0.7	3.3±0.5	0.11
66.9±8.1 ^b	94.1±4.5 ^{ab}	76.2±10.0 ^b	0.003
4.9±1.0	8.1±0.5	6.7±1.0	0.19
60.7±8.3 ^{bc}	90.7±7.0 ^{ab}	74.9±10.3 ^{abc}	0.01
311.6±42.8 ^b	431.1±23.7 ^{ab}	368.1±52.0 ^b	0.008
84.5±7.6 ^{ab}	86.6±12.0 ^{ab}	73.9±12.0 ^b	0.01
5.1±0.8 ^{ab}	5.2±1.0 ^{ab}	4.4±0.9 ^b	0.02
1.1±0.2 ^{ab}	0.9±0.1 ^{abc}	0.7±0.1 ^{bc}	0.03
ND	ND	ND	
ND	ND	ND	

sup. Different superscript letters a, b, c

0.05 by one-way ANOVA followed by Tukey's test.

ND, not detectable.

Table 7. Consumption of different caloric sugar-sweetened solutions

Measurement	Water	Glucose
Liver lipid content (%)	6.75±1.55 ^{ab}	8.89±0.42 ^{ab}
Fasting glucose (mmol/L)	195.1±16.0	225.3±36.0
Insulin (pmol/L)	216.7±22.0	301.6±84.6
Serum lipids		
Cholesterol (mmol/L)	2.03±0.15	1.83±0.09
TG (mmol/L)	1.01±0.12 ^b	1.13±0.16 ^{ab}
VLDL (mmol/L)	0.72±0.12	0.60±0.11
LDL-C (mmol/L)	2.31±0.28 ^b	2.57±0.37 ^{ab}
HDL-C (mmol/L)	1.00±0.15	1.26±0.16
Liver function		
ALT (U/L)	82.3±12.1	49.7±14.1
GGT (U/L)	4.42±0.48	3.43±0.61
Bilirubin (µmol/L)	2.56±0.49	2.07±0.28
Albumin (g/L)	42.1±2.0	37.3±3.0

*Values are expressed as the mean ± SEM of n=7-8 rats/group. Different rows indicate significant differences at $P < 0.05$ by one-way ANOVA. HFCS-55, high fructose corn syrup 55; TG, triglyceride; VLDL, very low density lipoprotein; HDL-C high density lipoprotein; ALT, alanine aminotransferase

by growing female rats on serum clinical measurements.

Treatment[†]	Fructose	Sucrose	HFCS-55	P-value
	3.64±1.06 ^b	6.40±1.34 ^{ab}	10.60±1.55 ^a	0.005
	173.1±18.9	214.0±19.1	246.7±49.1	0.51
	251.9±32.2	284.6±42.2	378.0±87.6	0.35
	1.82±0.11	1.89±0.19	2.19±0.23	0.50
	1.32±0.13 ^{ab}	1.55±0.12 ^{ab}	1.62±0.16 ^a	0.02
	0.64±0.05	0.65±0.07	0.76±0.07	0.73
	3.01±0.30 ^{ab}	3.55±0.27 ^{ab}	3.69±3.5 ^a	0.02
	1.10±0.09	1.04±0.14	1.22±0.15	0.66
	58.3±11.6	61.7±9.6	48.0±8.6	0.24
	2.71±0.51	2.86±0.51	3.14±0.94	0.34
	2.05±0.28	1.71±0.10	1.71±0.09	0.20
	38.1±3.1	35.9±3.6	38.1±2.6	0.64

†Different superscript letters a, b within the same row indicate significant differences ($P < 0.05$) followed by Tukey's test. Abbreviations are HDL-C, high density lipoprotein; LDL-C, low density lipoprotein; ALT, alanine aminotransferase; GGT, gamma-glutamyl

ALTERING VAPOR PRESSURE OF MIMIC PHEROMONE 2-PHENOXYETHANOL AFFECTS EFFICACY OF TRAIL- FOLLOWING BEHAVIOR IN RETICULITERMES SP.

Daniel Teoli

Introduction

Over the past several decades, extensive observation and analysis of termite behavior has taken place within the scientific community. One of the topics at the forefront of pertinent research involves exploring the behavioral intricacies of these small eusocial insects (Witting 2007), as well as their specialized reliance on certain chemical secretions [or pheromones] to remain biologically successful within their respective native environments (Matsuura et al. 2010).

Upon the completion of an extensive literature review, it is clear that among the many uses of chemical discharge to termites, some of the most heavily affirmed functions include the following: the expulsion of specific pheromones can serve as a mating signal to members of the opposite sex thus increasing the likelihood of successful reproduction (Bordereau et al. 2010); unique chemicals are internally manufactured and projected into the environment in order to signal danger to individual termites as well as operating as an alarm mechanism for entire colonies (Šobotník, Jirošová, and Hanus 2010); trail pheromones are produced in order to assist with important foraging navigation behaviors across termite societies while searching their surroundings for sources of sustenance (Howse 1984, 475-519).

Of particular interest to this study is the issue of alterations in the efficacy of trail-following behavior when the respective vapor pressure of mimic pheromones is manipulated. In many different species of termites, the workers secrete distinct pheromones from the sternal gland in order to mark a potential food source. Once the chemical compound is applied to the food source, the organic stamp can act as a map for other termites to travel along (Matsumura, Coppel, and Tai 1968). Natural inquiries arise as to how effective this strategy would remain once performed under a spectrum of unique temperatures.

It is important to mention that while many different species of termites utilize these techniques [and behaviors] of chemical utilization, the specific intrinsic properties of the compounds utilized can vary widely across the respective species. However, even with a breadth of unique compounds in consideration, a somewhat unifying tie was established in a study conducted by Sillam-Dusses et al. which linked the relative biological success of a given termite species to their efficiency and effectiveness in pheromone usage for foraging activities (2010).

With these facts in mind, a logical curiosity develops concerning what is an example of the active chemical that provides these said pheromones with

their power. While remaining cognizant that there may be differences among species, in an experimental study by Chen, Henderson, and Laine, it was found that *Coptotermes formosanus Shiraki* and *Reticulitermes* sp. were both attracted to the organic compound 2-phenoxyethanol (2-PhOH) in a close level of similarity to the attraction shown towards their natural pheromone counterpart (*Z,Z,E-3,6,8-dodecatrien-1-ol*) (1988). The source from where the group originally extracted the organic compound for experimental analysis is of great interest: a common Papermate ballpoint pen.

Therefore, not only does the knowledge available to the scientific community, thus far, have a strong grasp on the scope of functionality concerning pheromone secretion in termites, but, additionally, researchers have identified an analogous sample of chemical structure (e.g. an alcohol) that makes those aforementioned functionalities possible. A meaningful undertaking is to then proceed to explore more in depth characteristics of these specific organic entities and how they relate to *Reticulitermes* sp. utility.

2-phenoxyethanol has been extensively investigated in its own right outside the scope of termite behavior. For example, of strong interest to many aquaculture-focused laboratories is the anesthetic effect that 2-phenoxyethanol exhibits in underwater entities such as the musky octopus (Sen and Tanrikul 2009). Additionally, 2-phenoxyethanol has been studied concerning its usefulness in dermatological creams/lotions (Tokunaga et al. 2003), its reliability as an antimicrobial preservative in vaccines (Lowe and Southern 1994) and its effectiveness as a long term preservative for cadavers in dissection rooms (Wineski and English 1989). In its pure form, 2-phenoxyethanol maintains the appearance of an often colorless or sometimes light yellow viscous liquid with a melting point of 11-13°C, a boiling point of 247°C and a vapor pressure of 9.21×10^{-6} atm at 25°C (Oxford University).

Similar to all other chemicals, when existing within a liquid state, 2-phenoxyethanol is a volatile substance to a certain degree. Volatility is simply a measure of a substance's tendency to turn into vapor [or vaporize from a liquid to gaseous phase at a given temperature and surrounding atmospheric pressure]. Additionally, at any arbitrary temperature, substances with high volatility (ergo high vapor pressure) are more willing to vaporize than are substances of low volatility. Thus, highly volatile chemicals reach a unique equilibrium between the liquid and gaseous phase, with more of the substance existing in the latter phase (in comparison to those chemicals with lower volatility).

Generalized trends concerning the relationship between vapor pressure and temperature can be established and graphed; the aforementioned relationship has been conceptually illustrated in Figure 1 (above) in regards to two

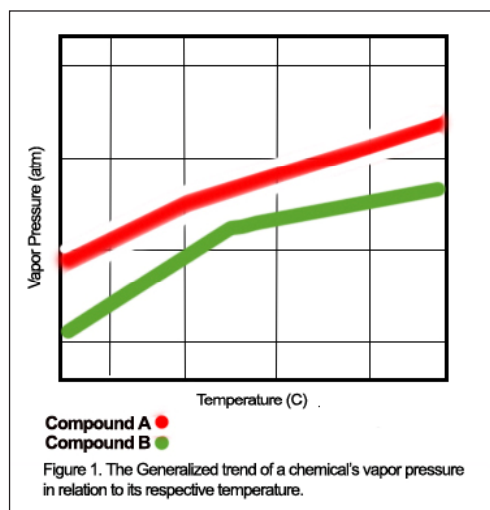


Figure 1. The Generalized trend of a chemical's vapor pressure in relation to its respective temperature.

hypothetical liquid compounds. Notice that vapor pressure does not depend only on experimental system characteristics (i.e. temperature), but also on the actual structure and identity of the underlying compound of interest.

Upon understanding how termites rely on pheromone signaling so heavily, another question immediately arises: how does the termite respond to [and what is the efficacy] the chemical of interest when it is presented at different temperatures (and therefore different vapor pressures), respectfully? In this paper, the answer to that question will be sought and discussed. The primary investigator hypothesized that lowering the temperature of the ink solution that contains the mimic pheromone 2-phenoxyethanol would result in the termites displaying a lower rate (time) of direct trail-following behavior. The proposed explanation for this hypothesized phenomena being that by decreasing the temperature of the ink solution, it would consequently lower the vapor pressure of the 2-phenoxyethanol component of the solution [and thus the mimic pheromone of interest would exist less in the gaseous phase and be sensed less by the referent insect's chemical receptors accordingly].

Once an accurate portrait concerning the efficacy of chemical pheromones is painted across a spectrum of temperatures, it may offer the potential to further explain evolutionary development of these fascinating organisms in relation to their natural environment and climate settings. Additionally, considerations can be given as to how seasonal changes might affect a given species' biological success.

Methods

Prior to beginning the study, the investigator clearly elucidated the independent and dependent variables of interest as the temperature of the mimic pheromone (ink solution containing 2-phenoxyethanol) and the termites' success rate of following an ink-drawn circle for 20 seconds, respectively. A selection of ten termites of *Reticulitermes* sp. origin (i.e. *Reticulitermes flavipes*) was chosen to serve as the sample for both the control and treatment groups. Upon sample selection, a circle was drawn with the ink solution at room temperature (22°C). A termite from the sample pool was chosen and placed precisely on the ink circumference of the circle. A timer was started once the termite made its first movement [which, in every trial, was within one second of placement].

Measurements were recorded (in units of seconds) as to the length of time that each individual termite followed the ink circle before deviating beyond 2 cm. in any direction from the marked circumference. Once the termite had followed the drawn circle for 20 seconds without deviating beyond 2 cm. from the line, it was recorded as a "completion". If a termite did not reach the 20 second mark before deviating beyond 2 cm. from the circle, it was recorded as an "incompletion" and the specific time was made note of for future statistical analysis.

The procedure of choosing a termite, preparing a freshly inked circle, and recording trial data was repeated for each of the ten termites individually. Upon completion of the ten replications, the termites were returned to a jar with their original wood chips and left to settle for five minutes.

The next stage was carried out in a similar manner; the only controlled manipula-

tion to the testing variables was that the mimic pheromone containing ink solution was chilled to a temperature of 4°C. Each termite was provided with a freshly inked circle with a writing instrument that was removed from the laboratory refrigeration unit immediately before tracing. Similar to the control methodology, all ten termites were tested based on their first movement for a maximum period of 20 seconds while staying within a distance of 2 cm. from the drawn circumference.

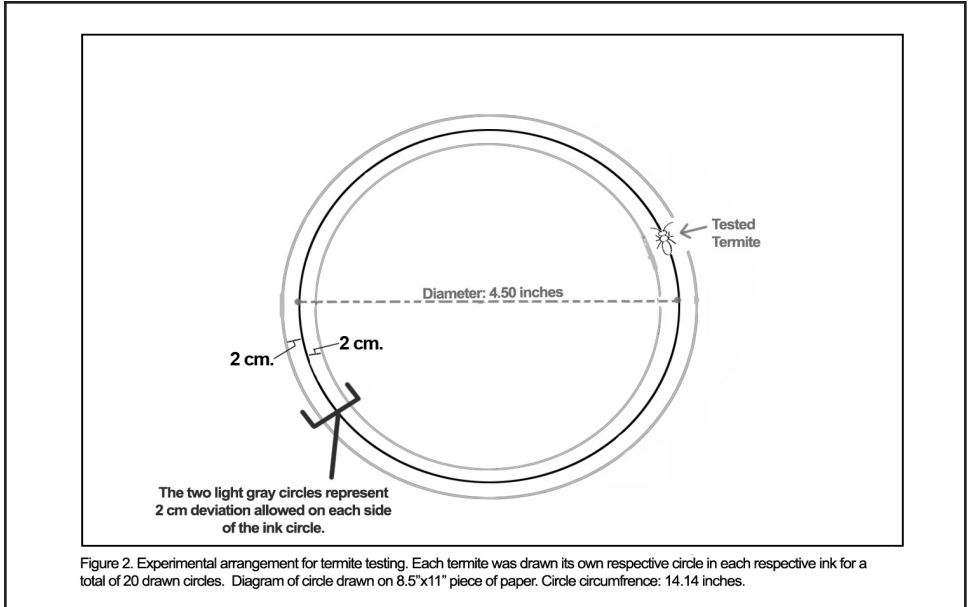


Figure 2. Experimental arrangement for termite testing. Each termite was drawn its own respective circle in each respective ink for a total of 20 drawn circles. Diagram of circle drawn on 8.5"x11" piece of paper. Circle circumference: 14.14 inches.

It is relevant to quickly make note that the time limit of 20 seconds was not a completely arbitrary determination, but rather chosen as to provide the best possibility of a termite gaining hold of the chemical trail – without allowing so much time to pass that the chilled ink solution would reach an equilibrium temperature with the environment (which, due to the direct relationship between temperature and vapor pressure, would impact the potential conclusion's validity). Figure 2 (above) depicts a diagram of the experimental setup that was utilized for this study.

Results

In the experiment of recording termite trail-following behavior while manipulating the temperature of the ink, the *Reticulitermes flavipes* test subjects displayed a significantly longer mean time ($p < 0.02$) when presented with the circle drawn with ink at a warmer temperature. Specifically, the mean time calculated for the treatment at 22° C was 19.20 seconds and the mean calculated for the treatment at 4°C was 11.60 seconds.

Additionally, standard error determination resulted in an output of 0.800 (for the treatment of 22° C) and a larger error output of 2.504 (for the treatment of 4°C). Replication was achieved in the experiment via the repeated use of the same ten specific termites for each given treatment group ($n = 10$).

Discussion

Observing the results procured from this experiment, one can see that the original hypothesis set forth by the primary investigator was supported. Interestingly, the termites showed a very high rate of completion (i.e. successfully following the mimic pheromone trail for at least 20 seconds) when the ink was at room temperature (22°C) versus when the same termites were presented with the mimic pheromone in solution at 4°C. These findings suggest that it is feasible that the alteration of mimic pheromone vapor pressure affects the efficacy of trail-following behavior in *Reticulitermes* sp. Namely, when the ink's intrinsic chemicals experience a high vapor pressure, they are more suitable to enter a gaseous phase than when the chemicals are at a lower vapor pressure. When the chemical mimic pheromone is more likely to be in a gaseous state (and thus readily permeate the air above the liquid solution), a termite is more likely able to lock onto the chemical trail and accurately display trail-following behavior. When the mimic pheromone experiences a low vapor pressure due to being held at a cold temperature, the chemical compound is comparatively more likely to remain in the liquid state and not permeate as much into the air – therefore resulting in the average termite experiencing more difficulty with maintaining the following behavior consistently, if even displaying the behavior at all.

However, the data collected did provide some unexpected results. While the solution at 4°C did show a statistically significant lower mean time of 11.60 seconds, the range of the times spanned a much wider time frame. The standard error for the warmer solution was only 0.800, while the standard error for the colder solution was a higher value of 2.504. There are several possible explanations for this variation. One reason for the difference could stem from individual characteristics unique to each termite: perhaps the chemical receptors of some of the termites were working at a different level of efficacy in contrast to those of their peers, and thus the scenario of longer runs and much shorter runs actualized (when it came to being presented with the mimic pheromone with a low vapor pressure). Amelioration of this potential risk could take form in future investigations via the utilization of a larger sample size (thereby reducing the possibility of test subjects with outlying efficacy levels [in regards to the functionality of their chemical receptors] having a significant impact on the data outcomes). Another possible explanation for the differences between the treatment groups' standard errors is a specific limitation encountered by the experimental design: while the ink solution at room temperature would have very little likelihood of changing

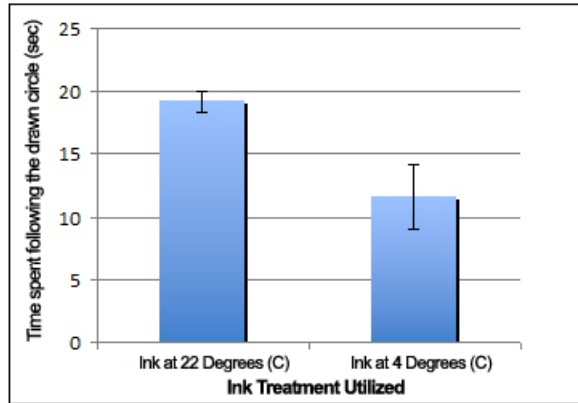


Figure 3. Time spent by termites following circles drawn with different temperature inks. The bars in the graph represent means (+/- standard error) for ten termites tested at both temperatures. A t-test returned a calculated p-value of 0.015 for data rendered.

temperature during a given trial (due to its already existing equilibrium with the environmental surroundings), the cold ink solution was prone to warm once removed from the freezer. Thus, there is the risk that while the cold ink solution was originally standardized to an identical temperature for each termite, the solution may have warmed by a different number of degrees across different specific trials once the termite was actually obtained and placed near the drawn line.

Further experimentation is needed in order to more clearly elucidate the relationship between chemical vapor pressure and termite trail-following behavior. Specifically, the future utilization of a refrigeration unit that could decrease the ink solution's temperature to a lower level (e.g. -5°C , -10°C , -15°C) than that capable of being reached in this experiment offers the potential to add additional support to the original hypothesis. If, as the ink gets colder, the termites show a further decreased mean following time, the vapor pressure hypothesis is concurrently strengthened. Additional data points would also allow the potential to further validate the investigative findings.

Additional future investigations should be undertaken that reduce the risk of the ink solution warming once the circle is drawn. Potential solutions include arranging the termite onto the paper before the ink circle is drawn (in order to reduce corresponding waiting periods), lowering the temperature in the room, performing the experiment completely within an insulated container, and using a thicker layer of ink. However, each of these possibilities would change a facet of the study and would thus require their own respective complete evaluation. Nevertheless, the findings would potentially offer additional support to the hypothesis of this study. A potentially useful future research endeavor would also observe any trends that arise from testing the termite groups with an inverse treatment in comparison to this study; namely, a new study might involve heating the mimic pheromone solution and comparing the results between room temperature (22°C) and warmer temperatures (e.g. 35°C). If the termites showed improved trail-following behavior when presented with heated mimic pheromones in comparison to that of those at room temperature, it would provide strong evidence towards solidifying the viability of the hypothesis concerning vapor pressure's relevance.

Based on the investigation's findings, future questions of interest arise as to how this potential connection between vapor pressure, trail-following behaviors, and temperature relate to *Reticulitermes flavipes* (and other termite species) as in their natural intrinsic environment and surroundings. In addition to impacting the vapor pressure, does altering temperature affect the termites physiologically (i.e. their chemical receptors)? While *Reticulitermes flavipes* often thrives successfully within regions of North America, even in the face of fluctuating seasonal temperatures, numerous other termite species often inhabit regions with predominately hot climates; in fact, it has been hypothesized that termites may have originated from South Africa (Bordy et al. 2009). This pending fact of origination from a hot, dry climate offers the feasibility of specific adaptations in the physiology (e.g. pheromone receptors) of *Reticulitermes flavipes* which have consequentially permitted it to survive in colder geographical regions. More studies must be performed in order to render a clear answer.

As mentioned earlier regarding the study of Sillam-Dusses et al., the effectiveness of a termite society's trail-following behavior has a direct correlation with its success (2010). With the efficacy of trail-following behavior in *Reticuli-*

termes flavipes successfully documented, a point of interest would be to examine other species for their own respective efficacy of pheromone usage at cold temperatures. Synthesizing these two facts leads to a logical explanation of the nature of the termite's habitat: certain termite species can thrive in regions with reasonably erratic climates (such as *Reticulitermes flavipes* within North America), yet other species are unable to continually inhabit regions of cold temperatures or harsh seasonal variations. In accordance with the findings of this study, the phenomena could be attributed in part to the likelihood of reduced efficacy in trail-following behaviors when located in these colder locations [arising from the reduced vapor pressure of their respective pheromones of interest in colder temperatures] and, thus, leading to the lower likelihood of successful foraging efforts, less fruitful reproduction cycles and, most importantly, the decreased likelihood of a species' biological success.

The exploration of outcomes encompassed by this study with *Reticulitermes flavipes* provided an insightful understanding of how climate factors (namely, temperature) could play a potential role in the success or failure of a given termite colony if translocated to a new geographic region. Additionally, it offered a viable hypothesis for physiological adaptations in a given *Reticulitermes* sp. which must have occurred during the species' respective evolutionary timeline in order to support continued (albeit less efficacious) trail-following behaviors when presented with pheromones with lower vapor pressures.

Acknowledgements

Special thanks to Dr. Katrina Stewart from the Department of Biology at West Virginia University. Without her provided resources, experience and support this investigation would not have been possible.

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RELATIONSHIPS EXIST BETWEEN CHEMISTRY SELF-EFFICACY IN COLLEGE STUDENTS AND ACADEMIC OUTCOMES IN CHEMICAL EDUCATION

Daniel Teoli

Introduction

Introductory and preparatory chemistry courses hold a particular importance to students across a wide range of academic specialties and majors. In addition to serving as a potential primer for students interested in the possibility of majoring in chemistry, introductory and preparatory chemical education has been actively integrated into the curriculum of other fields within the natural science spectrum (such as biology and physics). Additionally, under the umbrella of requisite coursework, it has gained a strong pertinence to applied sciences such as nursing, engineering, and exercise physiology (Tai, Sadler, and Loehr 2005).

Over the past few decades, the higher education system in the United States has witnessed deficient enrollment levels for individuals pursuing science-related majors. Additionally, a trend has risen at many institutions where attrition rates for first year STEM majors (science/technology/engineering/mathematics) have resulted in large proportions of the student body switching to other less science-heavy majors. In fact, while a study by Whalen and Shelley II (2010) noted that the trend seems to average at a summated 40% attrition rate over a given cohort's span from freshman to senior year, in some instances, attrition from STEM majors have reached as high as 45% in a single year. The possible dangers that could result in the future from a dearth of prospective science professionals in training today are numerous and hardly difficult to fathom. Shortages of appropriately trained engineers could limit future innovation and further catalyze the trend of native business entities seeking talent from other countries. This phenomenon could continue to the point that active recruitment by domestic academic engineering programs would be required to exponentially increase enrollment efforts, even at the risk of spreading departmental resources dangerously thin (Hutchison et al. 2006); a dearth of chemists could reduce the likelihood of discovering valuable drugs for the treatment of debilitating diseases, hinder the initiative for the future creation of environmentally safe products, and stunt the overall further development of the discipline (Lewis and Lewis 2007); a deficiency of exercise physiologists and nurses could render currently existing health-profession shortages to an even steeper gradient (Siela, Twibell and Keller 2009). Studies have shown that aggregated patient outcomes are less desirable in those hospital care environments which have higher proportions of nurses who have not sought and attained a bachelor's degree in nursing (Aiken et al. 2009). The importance of student success in preparatory and introductory chemistry curriculum, as these courses often serve as an academic gatekeeper of required

higher level curriculum for undergraduates in nursing bachelor's degree programs, is then paramount. If students seeking their bachelor's degree in an applied science have difficulty in introductory or preparatory level science classes, they may seek a means to reach their chosen career sans the successful completion of a bachelor's degree or possibly leave the field completely (Glossop 2001). This decision could come at the cost of decreased future earnings and/or lower patient/customer satisfaction.

Trying to accurately answer the question as to why the decline in science-related majors has taken hold cannot be easily encompassed by a singular motive. Rather, there are numerous factors that potentially play a role: the potential for higher paying careers in other sectors, a weakening of the academic advising system, and the internal self-efficacy beliefs (e.g. "I can [or cannot] do this successfully.") held by the given student concerning the field of study (Marra et al. 2009). Interestingly, self-efficacy has not only been supported in prior studies as a successful predictor of a student's academic major (and the respective retention within that major), but also bears a strong pertinence to future career decisions (Brown and Lent 2006). For the primary interests of this investigation, the remaining section of this paper will focus specifically on the subject of chemistry self-efficacy.

Attrition rates in preparatory chemistry classes are considerably high. At the referent four-year university where this study was conducted, out of the 998 students that were originally enrolled, only 644 remained enrolled through the end of the semester. Furthermore, only 379 of the original 998 received a final passing grade for the course, meaning that 62% of the original student population would need to either: retake the class, or seek an alternative major that did not require successful completion of the respective chemistry course.

Current research indicates one of the primary steps towards ameliorating the deficiency of students successfully obtaining degrees in the fields of science, engineering, technology, and mathematics is bettering introductory and preparatory level science classes offered to the students (Mervis 2010). More attention will be dedicated towards dissecting possible methods for improving entry-level chemistry courses in later sections of this paper.

One of the main goals of this study is to help expound upon what factors could have potentially played a role in the previously highlighted 62% of students that failed to successfully complete the course with a passing grade. Of primary interest is the exploration of the issue of self-efficacy was associated with the outcomes for the various groups of students. If self-efficacy were found to be relevant to the performance of the students in the course, then perhaps an effective way of improving future course outcomes could be found by improving self-efficacy across the student enrollment. Before proceeding, a preliminary discussion of what self-efficacy entails will follow.

Almost half a century ago, it was hypothesized and supported that a particular persuasive behavioral influence is determined by the respective individual's personally held belief network concerning their own abilities, as well as the corresponding results of their exertion (Bandura 1977). In other words, individuals interpret a self-analysis of their own abilities, and use that interpretation when deciding behavior. With time, Bandura went on to label the previously outlined beliefs as "Self-efficacy beliefs" (SEBs), and included them as a conceptual facet of his established social cognitive theory (1986). Analyzing his own studies, Bandura was the first to proclaim that SEBs play vital roles in the decisions people make

every day; self-efficacy affects choices to engage in or avoid a task, as well as the corresponding amount of effort that will be devoted towards fulfilling that decision. Furthermore, SEBs are utilized in an individual when internally deciding the level of difficulties one is willing to endure, as well as the levels of emotional pleasure/distress experienced during tasks (Usher and Pajares 2008).

On a similar note, SEBs have been shown to have a strong relationship with factors which affect motivational decisions: self-concept, anxiety levels, academic help-seeking, achievement goal orientation, and academic major orientation (Brown and Lent 2006). Additionally, past research by Schunk & Pajares has established that children who possess confidence in their own academic prowess engage in auxiliary tasks such as effective time management and demonstration of persistence; these traits increase the likelihood of academic success in comparison to fellow students with lower SEBs (2005). However, no insight as to how the results compare in college students engaging in preparatory chemistry curriculum has been procured.

Concerning collegiate education, extensive research has been conducted that supports that SEBs maintain a pertinence to students' success and achievement when engaging in particular curriculum: mathematics (Hall and Ponton 2005), engineering (Hutchison et al. 2006; Marra and Bogue 2006), nursing (McLaughlin, Moutray, and Muldoon 2008), robotics (Eric Zhi Feng, Chun Hung, and Chiung Sui 2010), legal studies (Christensen 2009), business (Elias 2008), and even social work (Rishel and Majewski 2009). Furthermore, it has been found that decreased (or relatively lower) levels of self-efficacy can lead to achievement-hindering effects in the classroom (Pajares and Urdan 2006).

With regards to satisfaction, Bandura found that SEBs can often positively impact a student's satisfaction levels, simply via techniques utilizing self-visualization of successfully completing difficult tasks and academic assignments (1997). On the other hand, general dissatisfaction with a course could potentially lead a student to attribute those feelings of discontent to low SEBs, even if they are not the true impetus. Furthermore, self-efficacy has a close bond with anxiety: high levels of class-specific anxiety can nullify the potential benefits of normally maintained positive self-efficacy towards particular tasks, thus rendering the student to doubt their own abilities (Usher and Pajares 2008). Therefore, a close mutual relationship is maintained in a dynamic state of existence within students among levels of anxiety, satisfaction, dissatisfaction, and SEBs. In many studies, the prior issues are considered and comparisons made about outcomes and levels of SEBs. Sometimes these analyses are even performed in very specialized academic fields with a narrow applicability to most college students. As an illustrating example of a narrow-focused niche, research conducted by Eric Zhi Feng et al. discovered that there is a connection between student satisfaction and self-efficacy in a collegiate cooperative robotics course (2010). On a tangential note, Hutchison et al. (2006) also establish that differences in SEBs do exist across the sexes in samples of students in certain instances of STEM curriculum. However, upon reviewing available literature, little was found as pertaining to self-efficacy and outcomes in chemical curriculum (regardless of chemistry's broad sweeping applicability to many college students and numerous important careers).

Nevertheless, there have been studies which involve chemistry and self-efficacy in certain frames of reference. Past investigations have been successfully

performed which identified instrumental scales which could be utilized for validly measuring self-efficacy in Turkish high school students (Aydin and Uzuntiryaki 2009). Additionally, a study by Smist explored aspects of the feasibility of increasing self-efficacy through laboratory experiments and exactly how self-efficacy compared in students at the end of the semester compared to at the beginning of the term (1993). No gender-based research has been found that specifically analyzes trends in self-efficacy levels and how they relate to academic predictive power and specific grade outcomes.

Purpose

This study aimed to locate, observe, and analyze the generalized relationship between a student's self-efficacy rating and the respective academic outcomes: namely, the student's own beliefs pertaining to chemistry-based tasks/outcomes, such as utilizing chemical formulas and equations, completing homework problems correctly, understanding abstract chemical concepts, understanding theories presented in the textbook, and achieving a good grade in the class. Throughout the remaining length of this paper, relevant SEBs pertaining to chemistry will be referred to as "chemistry self-efficacy" (CSE).

To ensure a full elucidation upon the specific intentions of this investigation, focus was directed towards the following: 1) Locating and analyzing trends that exist between class-wide collective data on pre-semester self-efficacy ratings and student-predicted grades, as well as with actual final course grades; 2) Recognizing and analyzing trends that exist between class-wide aggregated data on actual final course grades and post-semester self-efficacy ratings; and 3) Analyzing any trends that exist between male pre-and post-self-efficacy ratings vis-à-vis female pre-and post-self-efficacy ratings, while making a coupled observation of each group's respectively aggregated academic outcomes. Each sought relationship in this study was tested for intensity and significance.

Methods

Sampling Procedure

In the fall of 2007, eight different class sections of the referent university's preparatory chemistry course was offered. Across the eight sections, a total of 998 students were initially enrolled and a total of 644 students were enrolled at the culmination of the term. During the first week of the semester, students were provided with an attitudinal questionnaire which, among several other measures, explored student CSE. Additionally, during the last week of classes, students were provided with the same attitudinal questionnaire and asked to complete it with their updated attitudes and opinions. Approval was obtained from the referent university's IRB. All student participants were notified that completion of the survey was optional and were concurrently provided with an understanding of the research's purpose. Furthermore, students were clearly informed on the means that would be taken to ensure their privacy and the anonymity of their responses.

Mirroring the common methodology of self-efficacy studies, each student that successfully completed the pre- and/or post-attitudinal questionnaires' CSE items had the answers coded numerically (a=1, b=2, c=3, d=4, e=5). Afterwards, the coded scores for the six items of each individual student were collated and subsequently added together in order to reach a total, and then the summation was divided by six (the dividing figure was derived from the six CSE items utilized in the questionnaire). Upon dividing, a "mean score of CSE" was now rendered for each participant and thus allowed for further statistical data analysis. Any and all potentially identifying information for each student participant was stored in a separate data location, ensuring anonymity.

Pre-Semester Sample Description

There were a total of 998 respondents to the initial administration of the questionnaire during the first week of the semester. However, only 750 valid observations were available for analysis in regards to the items of interest for this study and thus rendering a successful response rate of 75.2%. Invalid responses met one or more of the following flaws: a) nonresponse by subjects to variables of interest (n=239, 23.9%), and b) out-of-range responses (n=9, 0.9%).

Of the study's 750 pre-semester participants, 377 (50.3%) were male and 373 (49.7%) were female for a closely representative sample of both the referent university's overall student body male-to-female ratio (namely, 51.8% male to 48.2% female) and the original 998 students enrolled in the respective course (namely, 53.6% male to 46.4% female). Furthermore, the initial sample consisted of 677 (90.3%) individuals reporting their race as Caucasian, 40 (5.3%) of the individuals reporting as African American, 13 (1.7%) of the individuals reporting as Hispanic, 14 (1.9%) of the individuals reporting as Asian/Pacific Islander, and 6 (0.8%) of the individuals reporting as a race other than the ones listed above.

For a more in depth portrait of the sample, additional demographics obtained from the initial administration of the questionnaire are provided in Figure 1, such as a proportional analysis of the students' semester standings and a macroscopic view of the breadth and frequency of academic majors present in the sample.

Figure 1, Initial Pre-Semester Sample Description of Student Participants by Gender, Race, Semester Standing, and Academic Major.

<i>Sample (Pre-Semester Sample Description)</i>		<i>n=750</i>
GENDER:	Male 50.3% (377) Female 49.7% (373)	
RACE:	Caucasian 90.3% (677) African American 5.3% (40) Hispanic 1.7% (13) Asian/Pacific Islander 1.9% (14) Other 0.8% (6)	
SEMESTER:	First semester freshman 78.1% (586) Beyond first semester 21.9% (164)	
MAJOR*:	Natural Science 19.6% (147) Social Science 2.3% (17) Applied Science 67.6% (507) Formal Science 0.3% (2) Non-Science/Other 10.2% (77)	

*Note: In order to efficiently analyze academic major presence, the following categorical framework was used:

Natural Science: biology, chemistry, earth sciences, physics

Social Science: anthropology, criminology, economics, history, psychology, and sociology

Applied Science: engineering and health sciences

Formal Science: mathematics, statistics, computer science

Non-Science/Other: business, philosophy, art, journalism, general education, etc.

Post-Semester Sample Description

At the end of the semester, an identical questionnaire was administered again to the students still enrolled in the course. Upon collection, a total of 315 valid observations were available for analysis in regards to the items of interest for this study. Again, invalid responses met one or more of the following flaws: a) nonresponse by subjects to variables of interest, and b) out-of-range responses.

Of the 315 valid observations, 157 (49.8%) were male and 158 (50.2%) were female. In regards to race, 282 (89.5%) were Caucasian, 16 (5.1%) were African American, 6 (1.9%) were Hispanic, 6 (1.9%) were Asian/Pacific Islander, and 5 (1.6%) were reported as an race other than the ones listed above. Additional sample demographics are provided in Figure 2 and, again, include the students' semester standings and the presence of academic majors.

<i>Sample (Post-Semester Sample Description)</i>		<i>n=315</i>
GENDER:	Male 49.8% (157) Female 50.2% (158)	
RACE:	Caucasian 89.5% (282) African American 5.1% (16) Hispanic 1.9% (6) Asian/Pacific Islander 1.9% (6) Other 1.6% (5)	
SEMESTER:	First semester freshman 76.8% (242) Beyond first semester 23.2% (73)	
MAJOR*:	Natural Science 21.3% (67) Social Science 1.9% (6) Applied Science 68.6% (216) Formal Science 0.3% (1) Non-Science/Other 7.9% (25)	

Figure 2, Initial Post-Semester Sample Description of Student Participants by Gender, Race, Semester Standing, and Academic Major.

*Note: In order to efficiently analyze academic major presence, the following categorical framework was used:

Natural Science: biology, chemistry, earth sciences, physics

Social Science: anthropology, criminology, economics, history, psychology and sociology

Applied Science: engineering and health sciences

Formal Science: mathematics, statistics, computer science

Non-Science/Other: business, philosophy, art, journalism, general education, etc.

Instrumentation

The measure of CSE utilized for this research study was obtained from a previously established construct titled "The Science Self-Efficacy Questionnaire" (SSEQ) which was originally created and validated among high school students and then later largely validated for college students by Smist (1993). The original SSEQ items utilized by Smist contained an anchored ranking scale in regards to the student's self-rated confidence towards performing a certain behavior (A=Quite a lot of confidence to E=Very little confidence). Items numbered 3, 5, 16, 18, 22 and 23 from Smist's 27-item construct (titled "Science Questionnaire") were included for use in this study, and are respectively listed on Figure 3 in an accurate reproduced form. Slight modifications were made to Smist's response options as they were adapted to the more familiar Likert 5-point scale (a=strongly disagree, b=disagree, c=neutral (or neither agree nor disagree), d=agree, e=strongly agree). No other modifications were made to the utilized items or their response options. The remaining unused items of Smist's "Science Questionnaire" were not included as they directly pertained to other scientific fields of study (i.e. physics and biology).

Scale Anchors:	a = strongly disagree		d = agree		
	b = disagree		e = strongly agree		
c = neutral (or neither agree nor disagree)					
	Rating:				
	Strongly disagree			Strongly agree	
I am very confident in my ability to use chemical formulas and equations.	-a-	-b-	-c-	-d-	-e-
I am very confident in doing chemistry homework problems well.	-a-	-b-	-c-	-d-	-e-
I am very confident in asking questions in chemistry class.	-a-	-b-	-c-	-d-	-e-
I am very confident in understanding concepts in chemistry textbook.	-a-	-b-	-c-	-d-	-e-
I am very confident about getting good grades in chemistry.	-a-	-b-	-c-	-d-	-e-
I am very confident in understanding abstract chemical concepts.	-a-	-b-	-c-	-d-	-e-

Figure 3, CSE-related Items and Scaling Utilized on the Pre- and Post-semester Student Questionnaires.

Note: Items pertaining to chemistry self-efficacy were isolated from the in-class 40-item questionnaire completed at the beginning of the semester and the later repeated administration the end of the semester.

Results

Pre-semester self-efficacy ratings and student self-predicted course grades

The results from a comparison of the initial student sample's pre-semester self-efficacy ratings and their corresponding self-predicted outcome (e.g. final course grade) are outlined in Figure 4 (below). As depicted within Figure 5 (below), the Analysis of Variance (ANOVA) output proclaims that there was a significant difference present between the students' self-predicted grade outcomes and CSE ratings ($p < .01$). A clear trend is visible when observing the gradient of students' pre-semester CSE (Pre-CSE Mean) against the progression of the students' self-predicted final grade for the course. More specifically stated, students that report-

ed higher self-predicted grades appear to correspond closely with students that simultaneously held relatively higher levels of initial CSE (i.e. the Pre-CSE Mean was 3.392 for students that anticipated an “A” at the start of the semester, while, on the other hand, the Pre-CSE Mean was comparatively only 2.720 for students that anticipated a “C” at the end of the term).

Predicted Grade	Pre-CSE Mean	N	Standard Deviation
4	3.392	364	.755
3	3.024	276	.607
2	2.720	91	.613
1	2.607	14	.876
0	1.533	5	.342
Total	3.148	750	.742

Predicted Grade Coding: 4=A, 3=B, 2=C, 1=D, 0=F

Figure 4, Comparison of Means for Student Self-Predicted Final Course Grades by the Student Reported Pre-Semester CSE Scores.

Predicted Grade	Sum of Squares	df	Mean Square	F	Significance
Between Groups	81.033	28	2.894	5.159	.000
Within Groups	404.434	721	.561		
Total	485.467	749			

Note: The mean difference is significant at the .01 level.

Figure 5, ANOVA: Comparison of Student Self-Predicted Final Course Grades by Student Pre-semester CSE.

Pre-semester self-efficacy ratings and actual student final course grades

The results obtained from comparing the means for the initial sample’s pre-semester self-efficacy scores with the sample’s actualized results [in regards to the preparatory course’s final outcomes] can be observed in Figure 6 (below). An ANOVA (see Figure 7) revealed that between the two points of interest, significant differences were present in the mean scores ($p < .01$). Again, a clear trend exists between the level of CSE held by the initial student sample and the resulting outcomes. Specifically stated, the higher final grades were characterized by students that held higher CSE at the beginning of the semester, while students who performed com-

paratively worse in the course had lower pre-semester CSE ratings. The Pre-CSE Mean for students that received an “A” at the end of the semester was 3.491, while, on the other hand, the Pre-CSE Mean for students that earned a “C” at the end of the term was a lower score of only 3.192. Furthermore, the results showed that the selection of students from the initial sample that eventually withdrew (W) from the course displayed the lowest mean for Pre-semester CSE at a value of 2.969.

Final Grade	Pre-CSE Mean	N	Standard Deviation
4	3.491	56	.768
3	3.356	95	.685
2	3.192	158	.643
1	3.150	103	.786
0	3.125	93	.747
-1	2.969	245	.750
Total	3.148	750	.742

Final Grade Coding: 4=A, 3=B, 2=C, 1=D, 0=F, -1=W

Figure 6, Comparison of Means for Actualized Student Final Course Outcomes by Student Reported Pre-Semester CSE Scores.

Final Grade	Sum of Squares	df	Mean Square	F	Significance
Between Groups	150.426	28	5.372	1.978	.002
Within Groups	1958.589	721	2.716		
Total	2109.015	749			

Note: The mean difference is significant at the .01 level.

Figure 7, ANOVA: Comparison of Actualized Student Final Course Outcomes by Student Pre-semester CSE.

Post-semester self-efficacy ratings and actual student final course grades

Upon completing an analysis of the post-semester sample’s reported post-semester self-efficacy ratings vis-à-vis the students’ actual overall final course grades, the aggregated results set forth that the students which earned comparatively higher final grades in the course actually displayed relatively higher levels of post-semester CSE. The trend remained consistent between all five potential grade outcomes (A, B, C, D, and F) and is clearly depicted in Figure 8 (below). Students

that ended the course with an overall final grade of an “A” experienced a Post-CSE Mean of 3.542, while students that earned a final grade of an “F” displayed a Post-CSE Mean of only 2.889. The respective findings previously outlined were shown to be significant ($p < .01$) via the results rendered via an ANOVA (see Figure 9).

Final Grade	Post-CSE Mean	N	Standard Deviation
4	3.542	48	.858
3	3.304	81	.773
2	3.167	107	.650
1	2.954	58	.697
0	2.889	21	.988
Total	3.202	315	.769

Final Grade Coding: 4=A, 3=B, 2=C, 1=D, 0=F

Figure 8, Comparison of Means for Student Self-Predicted Final Course Grade by the Student Reported Post-Semester CSE Scores.

Final Grade	Sum of Squares	df	Mean Square	F	Significance
Between Groups	70.699	23	3.074	2.587	.000
Within Groups	345.745	291	1.188		
Total	416.444	314			

Note: The mean difference is significant at the .01 level.

Figure 9, ANOVA: Comparison of Final Grade by Student Post-semester CSE.

Male Pre-semester self-efficacy ratings vis-à-vis Female Pre-semester self-efficacy ratings

A difference was found between the sexes within the initial student sample in regards to pre-semester self-efficacy ratings. Males showed the higher aggregated mean level of CSE possessed at a score of 3.222. On the other hand, females showed a lower aggregated mean level of CSE by rendering a score of only 3.073. Figure 10 (below) offers a complete view of the gender comparisons. The aforementioned results were shown to be statistically significant ($p < .01$) via an administered ANOVA (see Figure 11).

Gender	Pre-CSE Mean	N	Standard Deviation
1	3.222	377	.745
2	3.073	373	.732
Total	3.148	750	.742

Gender Coding: 1=Male, 2=Female

Figure 10, Comparison of Means for Student Gender by the Student Reported Pre-Semester CSE Scores.

Gender	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.168	1	4.168	7.639	.006
Within Groups	408.104	748	.546		
Total	412.272	749			

Note: The mean difference is significant at the .01 level.

Figure 11, ANOVA: Comparison of Gender by Student Pre-Semester CSE.

Male Post-semester self-efficacy ratings and Female Post-semester self-efficacy ratings vis-à-vis aggregated final grade outcomes

A comparative analysis between the genders within the post-semester student sample showed that males possessed a higher level of overall CSE at the culmination of the course when matched up against the females within the sample. The male post-semester CSE rating's mean was 3.251 and the female post-semester CSE rating was ascertained across the sample at 3.153. In regards to final course grades, males showed a slightly less desirable grade average of 2.15 in comparison to the females' final grade average of 2.30 for the course. Simply stated, though females performed better in the course, males still presented themselves as feeling more confident, respective to their own abilities. However, upon completing a statistical analysis, neither of the contrasts between the genders [in respect to the mean differences between post-semester CSE ratings and final grades] were shown to be of statistical significance ($p > .01$).

Gender	Post-CSE Mean	Final Grade
Mean	3.251	2.15
1 N	157	157
Std. Deviation	.744	1.150
Mean	3.153	2.30
2 N	158	158
Std. Deviation	.792	1.121
Mean	3.202	2.23
Total N	315	315
Std. Deviation	.769	1.136

Figure 12, Comparison of Means for Post-Semester CSE Ratings and Student Final Grades by Gender.

Gender Coding: 1=Male, 2=Female
Final Grade Coding: 4=A, 3=B, 2=C, 1=D, 0=F

			Sum of Squares	df	Mean Square	F	Sig.
Post-CSE Mean * Gender	Between Groups	(Combined)	.750	1	.750	1.270	.261*
	Within Groups		184.811	313	.590		
	Total		185.560	314			
Final Grade * Gender	Between Groups	(Combined)	1.794	1	1.794	1.391	.239*
	Within Groups		403.749	313	1.290		
	Total		405.543	314			

*Note: The mean difference is not significant at the .01 level.

Figure 13, ANOVA: Comparison of Post-Semester CSE Ratings and Student Final Grades by Gender. *Note: The mean difference is not significant at the .01 level.

Discussion

The findings of this investigation provide a new perspective as to how CSE exists across the student enrollment within preparatory level chemistry courses. The results also shed light on the manner in which initial levels of CSE relate to the students' own future outlook for themselves, as well as pertain to the actual end-of-semester outcomes realized by students. Furthermore, the results of this study show congruence with the research of Witt-Rose, where student-held SEBs were found to maintain a significant relationship with academic outcomes in a different collegiate science course, Anatomy & Physiology I (2003).

Further analysis of the statistical findings from this study on preparatory chemistry students revealed that the existing trends remain in harmony with several other important analogous studies relating to academics and self-efficacy: the phenomena that female students maintain lower science-related SEBs than their male counterparts (Smist 1994), high attrition rates still exist within entry-level courses of the hard sciences [i.e. physics, chemistry, etc.] (Mervis 2010), and students' personally held academic SEBs hold a significant relationship with academic performance (Hoffman and Spataru 2008). With the congruence between this respective investigation's discovery and those of the aforementioned studies, findings from studies in other STEM fields to entry-level chemical education are applicable to self-efficacy.

The importance of developing a strong presence of positive CSE in preparatory-level chemistry students early during the semester is of paramount interest to future research pursuits. Specifically, further investigation should be undertaken in order to offer a stronger support for the causal relationship between CSE and chemical education outcomes. It is vital to note that students who lack strong SEBs in academic settings do not merely sit passively on a metaphorical glass floor in regards, while students that do possess strong SEBs comparatively rise above the baseline. Instead, prior research shows that students that lack SEBs in academic settings can experience blatantly negative ramifications as a result of insufficient self-efficacy: a project performed by Klassen, Krawchuk, and Rajani found that undergraduates who lack strong academic-related SEBs concerning self-regulation displayed higher levels of procrastination in college (2008); an investigation by Walsh proclaimed that in a sample of nursing students enrolled in mathematics courses, academic-related anxiety was discovered in those students that did not

possess high levels of confidence in their own ability to solve mathematical problems (2008); similar results were found in a study by Bandalos and Yates specifically stating that students that did not possess high levels of academic self-efficacy were not merely neutral towards test outlook, but instead showed the presence of test anxiety (1995). Furthermore, research performed by Zajacova, Lynch and Espenshade found that students without high self-efficacy levels are more likely to have higher levels of academic related stress in their daily life (2005).

The aforementioned studies help to elucidate the absence of positive SEBs in a student. Its lack is not merely a situation that leads to neutral outcomes at the expense of only notable benefits, but rather the mere absence of positive SEBs has the potential to actively instill several severe negative outcomes instead. In light of these facts, it should be clear that the chemistry departments at academic institutions should not only try to maintain students' internal beliefs. Students should surpass a survival-only mentality, and replace it with an attitude geared toward excellence.

According to this investigation's results, students that entered the chemistry course with high levels of CSE were more likely to earn a higher grade at the end of the semester. Furthermore, those students that earned the higher final grades in the course had larger consequential increases to their own level of CSE at the end of the respective semester compared those students with less desirable grades and lower levels of CSE (aggregated). The cyclical reaction between achievement and self-efficacy appears to be viable. The level of post-semester CSE attained from a preparatory chemistry class essentially sets the stage for the initial level of CSE in a subsequent chemistry course, and likely impacts its eventual outcome. Perhaps the hardest part of the figurative equation is simply getting students started in the correct direction, toward CSE instead of away from it.

As the results of this study show, female students tend to have lower levels of CSE in comparison to males at the start of introductory level chemistry courses (see Figure 10). As previously outlined, across the spectrum science disciplines, females maintain lower levels of SEBs, which when observing female actual course outcomes to male outcomes, appears to be illogical. While, the specific findings outlined in Figure 12 did not show statistical significance ($p > .01$), they do nevertheless appear fascinating in nature: females maintained a lower level of post-semester CSE than males, yet concurrently maintained the higher mean grade outcome between the two genders. Future experimentation is needed to further explore this anomalous occurrence. However, one possible explanation is that females hold themselves to a higher standard than males as to what qualifies as satisfactory or unsatisfactory performance/ability (Correll, 2004).

To ameliorate the circumstances of female students holding lower levels of initial CSE, chemistry departments should strive to provide its students with strong support that both sexes can excel in the field of chemistry. A possible demonstration of this fact could include a brief, unorthodox lecture or assignment early in the semester where students learn about notable female chemists and proceed by writing a short essay about how being female and being successful in chemistry are not mutually exclusive. However, it should be noted that Wyer et al. (2007) found that such class-based attempts at influencing gender perception did not render any major results when applied in an undergraduate ecology course. Nevertheless, further research would be needed to expound upon the fruitfulness of its implementation in a chemistry classroom.

It remains pertinent to mention that while students with higher levels of CSE are more likely to successfully complete a preparatory chemistry course with a grade of A, B, or C – that fact does not ensure the successful matriculation into the next sequence of introductory-level chemistry courses. In other words, effort must still be given by the academic institution's chemistry department towards accurately guiding students that completed the preparatory course towards the logically following step. A study performed by Jones and Gellene found that even after successfully completing a preparatory chemistry course, approximately 53% of the students changed their major to a field that did not require any further chemistry curriculum (2005). Why this large proportion of the successful students decided to change majors is not known with absolute certainty, but a reasonable hypothesis is that at least some of the students were simply avoiding future requisite chemical education due to some facets of a science curriculum, such as intra-classroom competition and harsh grading curves (Seymour & Hewitt, 2000). In which case, it is a result that may have been lessened if the successful students had increased CSE during and after their respective remedial course.

Regarding techniques for raising student-held CSE, it is appropriate to introduce to the discussion valid research that has been shown to be effective in improving self-efficacy in general academic settings. Luzzo and Hasper performed an investigation that demonstrated the comparison of effects from two particular means of increasing self-efficacy in a student sample (1999). The first method Luzzo and Hasper utilized was based off of "vicarious learning" (VL). Essentially, VL can be encompassed by the act of an individual learning a new task, or new perspectives, by simply watching someone else perform. Luzzo and Hasper offered a video presentation about two college graduates whom were originally indecisive concerning their pursuit of a science-based major, yet after working hard and succeeding, both graduates excelled in their science curriculum, graduated and are now highly successful in their occupational endeavors. From merely watching the video, the student observers were provided with new perspectives of how experiencing difficulties in science curriculum can be expected and does not necessarily mean that they should immediately seek another field. The other technique used by Luzzo and Hasper focused on the facet of performance accomplishment (PA), differentiated from VL in the sense that the increase in self-efficacy arises from actual participation in a given activity. An example of PA would be to improve a person's self-efficacy pertaining to mathematical tasks by working with them to solve progressively harder problems and making certain that the student is cognizant of their progression to more complex problems. The researchers found that between the two methods outlined, while VL was useful, PA was more effective.

Applying both the VL and PA methodologies successfully to a chemistry course could prove beneficial for increasing student self-efficacy early in the semester. Different routes could be pursued for VL depending on the level of complexity or interaction desired by the academic institution. An entire lecture could be dedicated to a Q&A session with successful graduate students and/or professional chemists concerning their own personal backgrounds, academic hurdles, and how they decided to pursue a degree in chemistry. A 10-minute video could also be shown during the beginning of a lecture outlining and offering similar positive material to the students. Likewise, different techniques could be utilized to pursue the route of PA. Similar to the option available to VL, the amount of time

and effort spent towards the pursuit is dependent upon the respective institution. Approaches could range from the impromptu dedication of a portion of a single lecture towards engaging in PA tasks with the entire class, to consistent, outside-of-class small group meetings to practice tasks.

The previously mentioned application of enacting established group tutoring sessions is of high effectiveness and has been shown to improve outcomes among students under the premise that the tutoring entities are properly trained in ways to help struggling students and help boost SEBs (Margolis 2005). Simple techniques for potential tutors include seating the students in a round-table fashion so they can see and easily interact with each other, keep the meeting discussions on point and pertinent to the material of interest, and encouraging questions and active listening practices (Margolis and McCabe 2006). However, it is important to stress that if computer technology is to be utilized for any of the self-efficacy building exercises, it should be confirmed that each student possesses the needed level of computer and/or technological literacy required to successfully complete the tasks without any difficulties. As McCoy found, students that do not possess their own computer at home are often less proficient at operating a computer system and, if prescribed, negative effects upon SEBs can take place if the student is unable to effectively use the said technology (2010).

Ongoing and Future Research

Concerning the aims of future research, of primary interest are studies to further validate the findings of this investigation as well as explore additional relationships involving CSE. Additional insight should be sought as to if and how individual academic majors relate to student CSE in preparatory-level chemistry courses. A large sample, representative of a broad range of academic majors, may offer further information as to which particular undergraduate fields of study are more at risk for performing poorly in entry-level chemistry courses compared to other majors.

Additionally, further research should be sought to provide a more in depth, representative sample of races to analyze the potential relationship between a student's racial background and CSE. This study might offer deeper insight into the plausible association between student race and likelihood of success in introductory level chemistry curriculum.

In order to gain understanding into the seemingly curious results between males and females concerning post-semester CSE levels and final grade outcomes, future studies should seek an additional explanation of what might be causing these unexpected results. Factors such as differences between the sexes in regards to self-recognition of achievement levels could be causing the discrepancy.

Further investigations concerning the goal of increasing student CSE via new teaching techniques utilized by the professor may prove fruitful. In 2009, Akinsola and Awofala found that significant differences in outcomes occurred within a sample of mathematics student when one group was offered personalized instruction and the other group was offered non-personalized instruction; the personalized instruction had more positive outcomes. These findings raise the question if personalizing the instruction in preparatory chemistry courses would

result in more positive student outcomes, in direct comparison to standardized, non-personalized chemical instruction. Using computer adaptive homework and/or assignments which mirror the dynamic nature of the other computer based testing technologies, such as that used by the Graduate Record Examination (GRE) could achieve this personalization: students start the test with a moderately difficult question and the difficulty of subsequent questions depends on if the previous answer was correct or incorrect – at the end of the administration the resulting score is scaled appropriately in accordance with the difficulty level of questions correct. Extrapolating the techniques of the GRE to chemistry education could provide students with more pinpointed feedback as to their strengths and weaknesses concerning the assigned course material.

On another note, the development of novel and valid instruments for accurately measuring cognitive items such as CSE is imperative for offering new modes of interpreting data across dynamic sample populations. As demonstrated in the instrumental study of Silver, Smith Jr. and Greene (2001, extensive study efforts towards constructing new measures bestows greater variety to researchers concerning a wider breadth of applicable tools (such as what Smist achieved by remolding the SSEQ), and serves the useful function of offering further support for results that utilized alternative instrumental measures.

Lastly, future research should aim to offer predictive insight in regards to preparatory level chemistry education outcomes via the administration and analysis of additional cognitive measures such as perceived competence, learning self-regulation (intrinsic and extrinsic), and attributions of success.

Acknowledgements

Thanks to my research mentor Dr. Michelle Richards-Babb for making this research experience possible. If it had not been for her generosity and guidance with utilizing her laboratory, her datasets, and (most importantly) her knowledge of chemical education/student outcomes. I would never have had the opportunity to complete this investigation.

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Abbreviations

CSE - Chemistry self-efficacy

GRE - Graduate record examination

PA - Performance accomplishment

SEBs - Self-efficacy beliefs

SSEQ - Science Self-Efficacy Questionnaire

STEM - Science/Technology/Engineering/Mathematics

VL - Vicarious learning

BARRIER PROPERTIES OF GRAPHENE-BASED POLYMER NANOCOMPOSITES

Matthew S. Thompson with Dr. Sushant Agarwal and Dr. Rakesh K. Gupta

Abstract

Exfoliated graphite nanoplatelets (herein called graphene) are nanometer-thin platelets that are being extensively researched for their high stiffness, thermal conductivity, mass transfer barrier properties, and electrical conductivity towards developing a wide range of applications such as polymer nanocomposites (PNCs). These graphene-based PNCs (GPNCs) are expected to have better properties as compared to PNCs made using carbon nanotubes or nano-layered silicates.

Graphene platelets are generally hydrophilic in nature hence difficult to disperse in polymers. In the work described here, surface treatment of graphene using 3-aminopropyltrimethoxysilane (APTMS), as shown by energy dispersive x-ray spectroscopy (EDS), results in more hydrophobic graphene which shows better dispersion. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) images illustrate the effect of surface treatment on the dispersion of graphene into polyvinyl acetate (PVAc). Barrier properties of treated and untreated graphene in PVAc were measured by sorption tests of GPNCs in water at various filler concentrations and different platelet diameters which show that the graphene platelets form an excellent barrier against diffusion.

Introduction

Graphene is being studied extensively for its phenomenal structural, mechanical, electrical, thermal, and barrier properties. An atomically thick, two-dimensional layer of carbon atoms, graphene has recently sparked much scientific interest, with thousands of publications and several reviews dedicated to it (Mukhopadhyay & Gupta 2011; Potts et al. 2011; Kim, Abdala, et al. 2010). Among other applications, graphene shows great promise as an effective mass transfer barrier, with one sheet able to block gas permeation of atoms as small as helium (Bunch et al. 2008). These barrier properties are able to be transferred to graphene-based polymer nanocomposites (GPNCs); dramatic decreases in gas permeation can be achieved at very low filler levels (1-3 wt%) for a multitude of different polymer matrices (Kim, Miura, et al. 2010; Kim & Macosko 2009; Kim & Macosko 2008). Also, specialized applications requiring opaque packaging materials may utilize the ability of GPNCs to block high-energy light (Owen et al. 2010).

Similar to those of nanoclay or nanosilicate composites, graphene's barrier

properties are a result of the tortuous path diffusing molecules must endure (Paul & Robeson 2008; Rana et al. 2005; Statler & Gupta 2008); however, GPNCs show much greater barrier properties than other fillers at similar loading levels (Potts et al. 2011). While the gas barrier properties of GPNCs have already been investigated in some detail, liquid mass transfer barrier properties have not. However, the morphological characterizations and theoretical models developed for nanoclay and nanosilicate composites (Paul & Robeson 2008; Rana et al. 2005) should be applicable to GPNCs as well. In this work, the dispersion of exfoliated graphite nanoplatelets (graphene) into polyvinyl acetate (PVAc) is discussed, and results of sorption tests of GPNCs are presented to show that graphene does form a barrier to liquid water diffusion.

Materials and Methods

Materials

Two batches of graphite nanoplatelets (xGnP[®]) were purchased from XG Sciences, Inc., having platelet diameters of 5 μm and 25 μm , respectively. Reported platelet thickness from XG Sciences, Inc., were 7 nm, meaning platelets still contained multiple layers of graphene.

Preparation of Polymer Nanocomposites

The effect of surface treatment on mass transfer barrier properties was investigated by comparing samples with surface treatment, treated samples, to those without, untreated samples. Surface treatment was performed by ultrasonically treating as-received platelets in dimethylformamide (DMF) at a frequency of 50% for 20 sec, adding an equal mass of APTMS to the mixture, and ultrasonically treating again for 20 sec at 50%. The mixture was stirred overnight, filtered, washed with acetone, and dried in an oven at 75°C. Treated and untreated material were, then, ultrasonically treated in isopropyl alcohol (IPA) at 50% with 5 sec pulses, separated by 15 sec breaks, for a total ultrasonication time of 30 min to separate platelets. IPA was then evaporated from the mixture using a hot water bath at 80°C, and the material was dried in an oven at 75°C.

Desired concentrations of graphene and PVAc were mixed using an internal mixer, using 60 g batches at 110°C for 5 min with a blade rotation rate of 125 rpm. Mixed material was then compression molded in a 30-ton press using a 15 cm x 15 cm square mold of 0.5 mm thickness at 116°C and 15 ton for 4 min. Molded material was cut into 2.5 cm x 2.5 cm square samples.

Measurement of Barrier Properties of Graphene

Sorption tests were performed to measure the barrier properties of graphene to water diffusion. Dry sample mass and thickness were measured to the nearest μg and μm , respectively. Samples were placed on wire-mesh stands in deionized water to

allow them to sit vertically for even diffusion into both sides of the samples. The samples were weighed on the same electronic balance periodically by removing from water, drying the surface with KimWipes®, and taking the sample weight 10 sec after placing on balance. Independent variables for sorption tests were the use of surface treatment, filler concentration (0.1, 0.2, 0.5, 1.0, and 1.5 wt%), and platelet diameter (5 and 25 μm). Sample jars were stored at room temperature (about 23°C).

Results and Discussion

Characterization of Graphene Platelets

Shown in Figure 1 are scanning electron microscopic (SEM) images of the as-received graphite platelets, 5 μm platelet diameter. In Figure 1-a, the accordion-like structure of the platelets can be seen. This results from the method of production of xGnP® by volatilizing intercalated compounds within the layers of graphite. With increasing magnification, the flaky, layered structure of xGnP® can be seen to the limits of SEM imaging, shown in Figure 1-b, as well as at greater magnifications, as shown by the transmission electron microscopic (TEM) image of a GPNC in Figure 2.

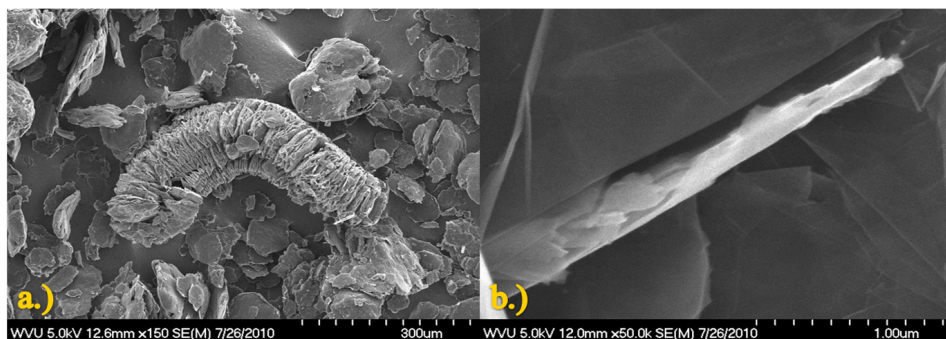
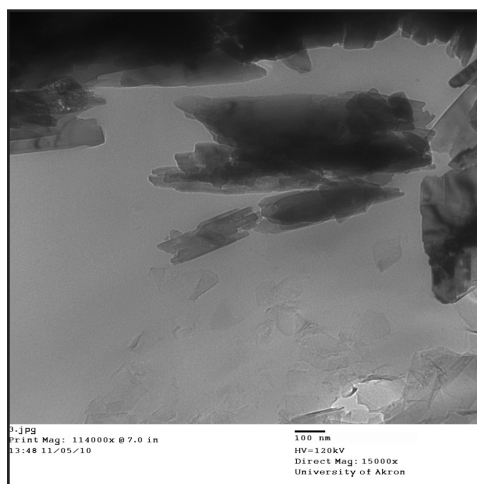


Figure 1, SEM of As-Received 5 μm -Diameter Graphite Platelets

a) Accordion-like structure of xGnP®; b) Layered, flaky nature of xGnP®.

Figure 2, TEM of 1.5% 5 μm -Diameter Graphene/PVAc, 100 nm.

The energy dispersive x-ray spectrometric (EDS) results comparing treated and untreated 5 μm -diameter graphene are shown in Figure 3. Results of the treated sample, the dotted line, show a replacement of oxygen surface atoms with silicon atoms, compared to those of the untreated sample, the solid line.



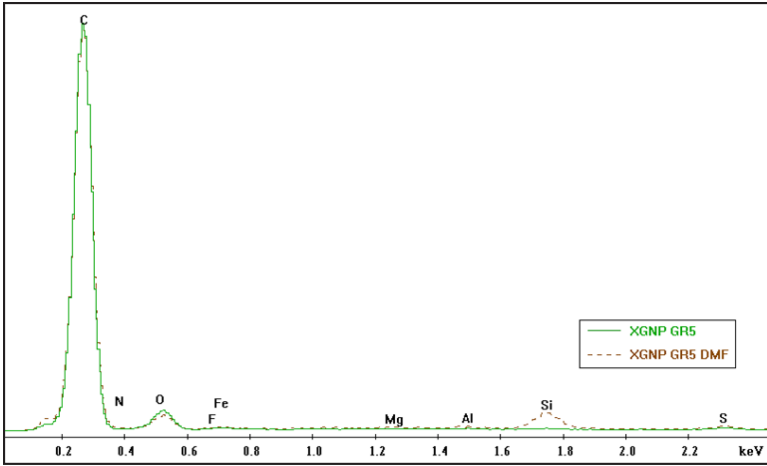


Figure 3, EDS Results Comparing Surface Treatment Techniques

Measurement of Dispersion in Polymer Nanocomposites

The effects of filler concentration, surface treatment, and platelet diameter on the dispersion of graphene into the polyvinyl acetate matrix are shown in Figure 4. Samples were fractured under liquid N₂ and coated with an electrically conductive material, and SEM images were taken of the fracture surface. Graphene platelets appear as white horizontal lines, perpendicular to the direction of diffusion, and all other markings result from fracturing the polymer. This morphology, in which the platelets align parallel to one another, results from compression molding. SEM images of unmolded samples were acquired and showed unaligned platelets.

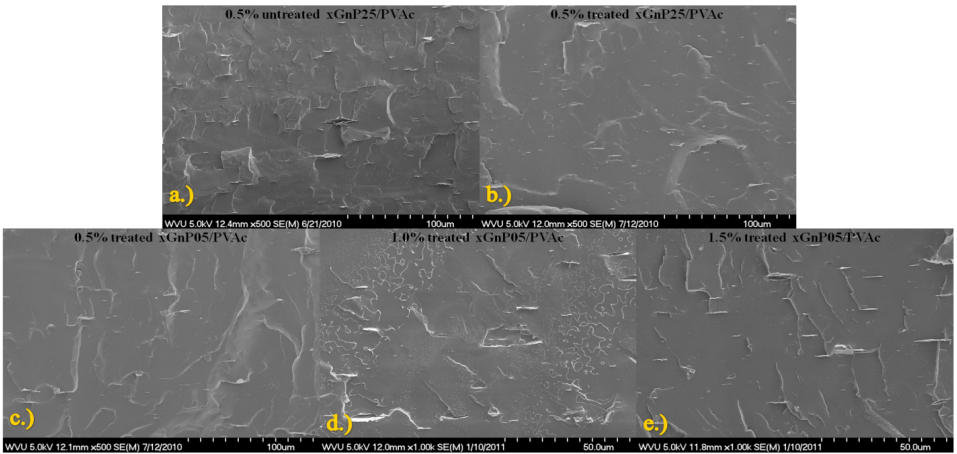


Figure 4, SEM of Dispersion of Graphene into Polymer

a) 0.5% untreated 25 μm -diameter graphene/PVAc, 100 μm ; b) 0.5% treated 25 μm -diameter graphene/PVAc, 100 μm ; c) 0.5% treated 5 μm -diameter graphene/PVAc, 100 μm ; d) 1.0% treated 5 μm -diameter graphene/PVAc, 50 μm ; e) 1.5% treated 5 μm -diameter graphene/PVAc, 50 μm

The amount of platelets visible increases with increasing concentration of filler, Figure 4-c,d,e. Furthermore, fewer platelets can be seen in the treated sample, Figure 4-b, than in the untreated sample, Figure 4-a, because particles are smaller; therefore, dispersion is better. Average particle sizes for the 25 μm-diameter sample, Figure 4-b, are larger than those for the 5 μm-diameter sample, Figure 4-c. Though particles do appear larger for the 25 μm-diameter samples than for 5 μm-diameter samples, platelets do not appear to actually be 25 μm or 5 μm in diameter.

Measurement of Diffusion Coefficients

Figure 5 shows the normalized mass gain for a typical sorption test; the average ratio of mass uptake, M_t , to equilibrium mass uptake, M_{∞} , of four samples each is plotted versus the square root of time over average initial sample thickness for all concentrations of treated 25 μm-diameter graphene/PVAc. Tests were not started at the same time, and the unfilled PVAc is the only test to reach equilibrium at the time this article was written. Therefore, for all other tests, an estimated M_{∞} was used. Due to the slightly hydrophilic nature of the graphene platelets, the mass uptake and time to reach equilibrium are proportional to filler concentration. From individual sample plots as in Figure 5, the diffusion coefficient was calculated from the slope of the initial linear section as per Equation 1, where D is the diffusion coefficient (Koros & Zimmerman 2003):

$$(1) \text{ slope} = \frac{4}{\sqrt{\rho}} (D)^{\frac{1}{2}}$$

The calculated diffusion coefficients of all sorption tests are shown in Table 1. All presented values are intermediate results because sorption tests are still ongoing at the time this article was written. In general, diffusivity is inversely proportional to filler concentration and surface treatment, and though 5 μm-diameter platelets yielded slightly lower diffusion coefficients, platelet diameter had little effect on diffusivity.

Figure 5, Normalized Mass Gain for Sorption Test of Treated 25 μm-Diameter Graphene/PVAc

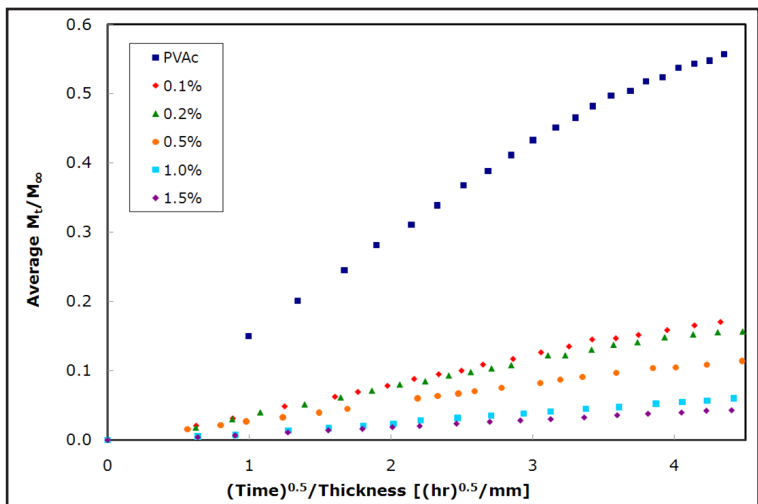


Table 1, Calculated Diffusion Coefficients

Treated Sample	Diff. Coeff. (cm ² /min)	S.D. (cm ² /min)
Pure PVAc	7.05E-07	4.6E-08
0.1% t. xGnP25/PVAc	5.47E-08	4.7E-09
0.2% t. xGnP25/PVAc	4.77E-08	3.1E-09
0.5% t. xGnP25/PVAc	5.23E-08	5.4E-08
1.0% t. xGnP25/PVAc	5.76E-09	4.1E-10
1.5% t. xGnP25/PVAc	3.15E-09	2.0E-10
0.1% t. xGnP05/PVAc	4.30E-08	1.6E-08
0.2% t. xGnP05/PVAc	2.35E-08	1.0E-09
0.5% t. xGnP05/PVAc	2.18E-08	1.2E-08
1.0% t. xGnP05/PVAc	6.27E-09	5.4E-10
1.5% t. xGnP05/PVAc	3.21E-09	4.0E-11
0.1% un. xGnP25/PVAc	1.08E-07	2.5E-08
0.2% un. xGnP25/PVAc	6.51E-08	4.5E-08
0.5% un. xGnP25/PVAc	4.20E-08	2.3E-08
0.1% un. xGnP05/PVAc	1.47E-07	1.5E-08
0.2% un. xGnP05/PVAc	6.32E-08	3.6E-08
0.5% un. xGnP05/PVAc	3.51E-08	1.1E-08

Conclusions

Among its potential structural and electrical applications, graphene is applicable as a mass transfer barrier for packaging applications. In the work presented here, graphite nanoplatelets were separated and dispersed into polymer, and the effects of filler concentration, surface treatment, and platelet diameter on the diffusion of water into the resulting GPNCs were investigated.

Graphene serves as an excellent barrier to water diffusion, dramatically lowering the calculated diffusion coefficient with very small filler concentrations. Surface treatment improves its barrier properties further, while platelet diameter has little effect. Future work includes further tests at various temperatures, including temperatures above the glass transition temperature of PVAc. The effects of surface treatment on graphene platelets will be confirmed using Fourier transform infrared spectroscopy (FTIR), and additional TEM images of GPNCs will be acquired. Also, additional tests on mechanical, thermogravimetric, rheological, and other properties will be performed.

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