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The Impact of Age and Gender on Reaction Time While Texting and Driving

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Abstract

Although distracted drivers are claiming more and more lives each year, drivers continue to perform dangerous behaviors behind the wheel of a moving vehicle. Of all driving distractions, texting and driving has proven to be one of the most dangerous. This research investigated the effect of text messaging on driver reaction, and whether the effect varied as a function of gender. Thirty-five Wichita State University students ranging in age from 18-29 participated in 5 different experimental conditions, a driving only condition, manually texting while driving, manually texting only, verbally texting while driving, and a verbally texting only condition. Reaction time was measured by the participant braking when the car in front of them braked. The participants were also asked to rate the perceived risk of texting and driving on a five-point scale. The results indicated that reaction times in the driving only task were significantly faster, compared to the task of driving and manually texting. There was evidence of a trend suggesting that women perceived the risk of texting to be greater than men, especially after completing the driving and texting task.

Introduction

Driving under normal circumstances can be a complicated task on its own. Adding distractions such as cell phone usage (texting, calls, and maps), applying makeup, and arguing with passengers makes it much more difficult. Research by Madden and Lenhart shows that there were 5,870 fatalities and 515,000 injuries in 2008 due to some form of driver distraction (2009). Their research also shows that teen drivers are generally at a much higher crash risk than other drivers. It is believed that driving inexperience may account for the significant risk faced by young drivers. In 2009, Alex Brown, a 17-year-old high school senior, was fatally crushed by her pick-up truck. This unfortunate event was the result of a few distracted moments of texting while driving. The article featuring Alex's story mentions her texting four friends around the time of her accident. Her mother is currently one of many fighting to make texting and driving illegal in the state of Texas (Chammah, 2013).

Past research has brought to light the true dangers of texting while driving. Research indicates that the deaths associated with texting while driving are becoming more common. Despite the new advances in technology and convenience of hands free devices the risks have not been reduced. The research conducted investigates further into the relationship between gender, age and reaction time.

Literature Review

General Information

In 2008, one in every six vehicle fatalities was caused by a distracted driver. A study conducted by Wilson and Stimpson (2010) from 1999 to 2008 revealed that a total of 51,857 deaths were caused by driver distractions, including cell phone usage. They also reported a 30% increase in fatalities caused by the use of cell phones from 2001 to 2007. The study shows that for every one million additional text messages sent per month, driving fatalities are predicted to increase 76%. Texting and driving is currently banned in 35 states, and many groups across the country are urging for it in the states that have not yet done so (Christoffersen, 2012). The analyses of legislative action in Connecticut have shown that more severe penalties can reduce texting while driving and its effects (Christofferson, 2012). Unfortunately, even in the states where texting and driving is banned it is becoming more and more difficult to monitor.

Reaction Times

Natural reactions can save people from the threats that surround them in everyday life. Unfortunately, texting and driving slows down our reaction times, opening the door to accidents. Reed & Robins (2008) found that reaction times to trigger stimuli tended to be higher when reading or writing a message. A study conducted by Burns et al. (2002) also found that drivers' reactions were significantly slower with constant mobile phone conversations. The slowest average reaction time was reported for drivers responding to a visual reaction time task while trying to compose a text message. Reaction time increased 33% from 1.2 to 1.6 seconds. This suggests that participants were significantly more likely to be slower to respond to the reaction time stimuli if engaged in concurrent text messaging. Research conducted by Caird & Scialfa (2004) reviewed 84 published scientific articles, covering seven years of investigation into the effects of cell phone use on driving. Sixty-eight of the articles measured driving performance while using a cell phone, and 16 articles were epidemiological studies that examined cell phone usage and its relationship to vehicular crashes. Many of the articles reported that conversing on a phone affected lane-keeping, speed, headway, and event detection. The researchers conducted a meta-analysis to evaluate the reported effects of cell phone use on driver performance. Three performance measures were considered: reaction time to critical events, driving control variability variables, and driving speed. The study clearly shows that using a cell phone conversation and information processing to simulate a distraction task negatively impacts performance. The largest effect was seen on reaction time to a variety of stimuli. From the larger set of studies, 18 adequately reported reaction time. Results showed an increase in reaction time of about ¼ of a second in the presence of a cell phone distractor for all studies that were analyzed. An important point is that the mean reaction time increased similarly regardless of whether the drivers use a hand-held or hands-free phone. The results also showed that conversations on cell phones, both hand-held and hands-free, negatively influence driving performance and increase crash risk. Responses to critical events and the ability to maintain vehicular control are hampered. The negative effect is larger for cell phone usage in response to critical events than for vehicular control, but driving variables such as lane position and headway variability did show smaller effects. On-road driver behavior tends to be worse than driver performance assessed in settings using a driving simulator. Due to limitations in the available published literature, a number of questions remain unanswered.

Researchers have recently begun to study the effects of texting on driver behavior. Burge & Chaparro (2012) began their study on texting and hazard perception by reviewing a set of articles and statistics demonstrating that drivers who are engaged in text messaging while in a driving simulator reported a slower reaction time. Burge & Chaparro (2012) used a low fidelity simulator, similar to the one used in the current study, to assess hazard perception when drivers were texting. They focused on the ability of drivers to successfully detect events that could cause a collision apart from speed and lane control. Two text message conditions were used to compare the effects of cognitive load. The first condition was a copy-text and the second, an alphabetize-text condition. The two conditions represented low vs. high cognitive load. Signal Detection Theory was used to provide information on missed hazards and false alarm data. This helped assess the degree to which drivers compensate for engagement in text messaging and their ability to discriminate hazards when distracted.

They reported a significant effect of the texting task on the number of missed hazards compared to a baseline drive-only condition. The drivers missed more hazards when completing the alphabetize-text task compared to the copy only conditions. There were no significant differences between the baseline and copy-text conditions. Interestingly, they showed that when completing the copy-text task participants were significantly more likely to respond to potential hazards than in the alphabetize-texting task. There was no difference shown between the baseline and copy-text conditions, nor between the baseline and alphabetize-text conditions. They reported that results showed a significant difference in reaction time for the texting, alphabetize-text and baseline, copy-text, and alphabetize-text conditions. They also showed that drivers missed more hazards and were slower in responding to the hazards when performing the more difficult alphabetizing texting task. Signal Detection Theory analyses indicated that drivers adopt a more liberal response criterion in the copy-text condition relative to the alphabetized-text condition. This resulted in fewer missed hazards but more false alarms. The poorer performance in the alphabetized task may be due to competition for a focal vision between the driving and text-messaging task. Drivers had to choose between looking at the phone or the driving scene. In addition to driver reaction time, investigators assessed the effects of distraction using a variety of other dependent measures, including driver glances on and off the road, speed control, and vehicle lane control. A summary of these findings is reported below.

Glances/Attention to Road

Libby & Chaparro (2009) investigated the effects of texting on driver glace behavior. Unlike talking on a phone, entering a text message may increase the number and duration of glances away from the roadway, thereby increasing a driver's risk. Libby & Chaparro had the participants complete three different tasks: 1) driving without a cell phone, 2) driving while talking on a cell phone, and 3) driving while texting on a cell phone, participants were instructed to categorize words appearing on billboards along the side of the road. They were asked to respond either by phoning it in verbally or by texting. A driving simulator was used to measure the driving performance.

The driving-dependent measures included the

number of times the driver's eyes left the roadway, mean driving speed, and reaction time. Drivers in the text messaging condition took their eyes off the road more often than in either the cell phone condition or the verbal response condition, had significantly slower reaction times to peripheral letter targets, drove more slowly, and exhibited greater variance in their lane position. Their results were consistent with the findings of Reed & Robins (2008) who reported that texting subjects glanced away from the road environment 40% of the time, as opposed to only 10% when undistracted.

Speed

Speeding is a dangerous act in itself, and adding a more difficult task like texting increases the risk of causing an accident. Caird, Scialfa, Ho, & Smilys' (2004) research revealed a small effect (average .26, median .2) of cell phone usage on driving speed. More specifically, results showed that drivers tended to drive more slowly while using a cell phone. Cell phone usage does not impact drivers' speed as significantly as it does their reaction time or vehicle control. However, it can still be a critical factor. At higher speeds, a quarter of a second made a difference between striking a vehicle or pedestrian and avoiding a collision. Studies show that individuals are aware of danger when texting and driving, and they are shown to slow down when they are preparing to read or send a text message.

Vehicle Lane Control

Vehicle Lane Control is an important aspect to consider when studying texting and driving. Studies show that the more an individual texts and drives the more likely he or she is to unintentionally cross lanes. Reed & Robbins (2008) conducted a study that showed an inconsistency in keeping vehicles in correct lanes. Specifically, there was a 70% increase in variability of lateral lane positioning, and a 28% increase in lane excursions. There was a 104% increase of drivers consistently missing road signs instructing lane changes. The study results showed that the driving behavior of the participants was impaired by concurrent text messaging tasks, and that writing a text message is significantly more impairing than reading a text message. A limitation of this study could be that the participants were tested on a non-familiar road, but whether or not this was a concern of the researchers, was not addressed by the article.

Passengers or Lone Driving

An important issue to consider is whether all forms of distractions are equal in their effects. Holding a conversation with a passenger is not unlike holding a cell phone conversation and thus could have a similar effect. However, studies show that drivers are more likely to drive safely and attentively with a passenger in the car because they are likely to have the passenger text or call for them. Recent findings (Drews, Pasupathi, & Strayer, 2008) show that drivers conversing on a cell phone exhibited greater lane keeping variability than participants conversing with a passenger. The authors reported that passengers are more likely to talk about the surrounding traffic, and that passengers tend to support the driver by directing attention to the surrounding traffic when they feel it is necessary.

Age and Gender

Many investigations on driving and distraction have been conducted on young novice drivers and their texting behaviors while driving. According to a study by Madden & Lenhart (2009) one in three teens, ages 16 - 17, say they have texted while driving. That translates into 33% of American teens ages 16 - 17 texting while driving. Fifty-two percent of teens, between ages 16 and 17, who own cell phones say they have talked on a cell phone while driving. While 48% of teens ages 12 - 17 say they have been in a car when the driver was texting, and 40% say they have been in a car when the driver used a cell phone in a way that put themselves or others in danger (Madden and Lenhart, 2009). Furthermore, McEvoy et al. (2006) identifies young drivers (18 - 30) as being significantly more likely to text while driving than older drivers. Similar research by Gras et al. (2006) found that among Spanish drivers, 19% admitted to texting on highways and 23% on rural roads at least once a month. A survey of Swedish drivers found that on average one text message was sent per month while driving, with drivers between 18 and 24 sending three texts per month, suggesting that younger drivers are much more likely to text while driving than older drivers (Thulin & Gustafsson, 2004). The National Highway Traffic Safety Administration, a section of the U.S. Department of Transportation, has reported that drivers under the age of 20 had the greatest portion of distracted drivers. Driving impairment caused by texting is shown to be more significant in females than males. Females tend to drift into other lanes more often than males while distracted by texting. They do however have a larger reduction in speed when attempting to text and drive, reducing the amount of danger they may cause to others (Reed & Robbins, 2008). An article published by the Litchfield County Times on February 13, 2012, mentions that men in Connecticut are more frequent offenders than women when it comes to texting and driving. A law was passed in Connecticut in 2006, banning the use of handheld cell phones while driving and text messaging while driving. Since then, men have received more citations for texting and driving. The article shows that male drivers have received about half of the distracted-driving citations annually for six years in a row. Last year in Connecticut men received 16,000 tickets while women received approximately 13,000. Two years before, men received about 25,000 and women received 21,000. These figures have gone down approximately 9,000 for men and 8,000 for women since the law has been in place (Christoffersen, 2012). These results suggest that the laws passed by legislation can play a role in decreasing infractions. When it comes to gender and age, no specific group is immune to the risk of texting and driving.

Technologies

Many cell phone providers have upgraded phones for the convenience of the customer. For example, many cell phones have a wand that can be used to write out a text instead of typing it in. Some phones even have the capability of generating texts from voice input. A recent study (Crandall & Chaparro, 2012) found that texting and using a touch screen phone resulted in poorer vehicle control compared to a physical keyboard. The difference is that physical keyboards allow the user to recognize finger placement on the raised buttons by touch rather than sight. Although these new technologies have not done away with the risk that texting and driving poses, some of the features require less attention towards texting, which in turn allows more attention for driving.

Methods

Participants

Participants included 33 individuals between the ages of 18 and 29, with a mean age of 21.3 (SD = 3.38). Nine participants were male, 24 were female. All participants were undergraduate students chosen

from the SONA Experiment Management System at Wichita State University. The students were all currently taking a Psychology class, and were granted 6 SONA credits for participating. The subjects all had normal vision and were required to have at least two years of driving experience. The mean of driving experience was 6.15 years (SD = 3.4).

Procedure

The purpose of this study was to observe the relationship between age, gender and reaction time. A Latin Square was used to decide in what order the participants would conduct each condition. To begin the experiment, the nature and purpose of the study was explained to the subjects. All participants were required to sign a consent form stating their wish to participate. A visual acuity test was then conducted to ensure the participant had 20/20 vision. Then, each participant completed a background survey. The survey consisted of 24 questions asking participants how many years of driving experience they had, their gender and age, the type of phone they had, if they ever texted and drove, if they talked on the phone while driving, how risky they felt texting and talking on the phone while driving is, and the type of keyboard they used to text. Before using the driving simulator, a fan was turned on to minimize any feelings of dizziness caused by the simulator. Next, the participants had a 2-minute practice session for each condition to ensure the proper use of the simulator and phone by the participants. If the participant felt comfortable with the practice sessions, the five counterbalanced scenarios were conducted. Every subject participated in each scenario. Each participant took approximately 75 minutes to run. Each condition was 12 minutes long, with the alerts for a new text message arriving randomly. The text messages consisted of 10 numbers. Four of the five conditions included text messaging. There was one driving only condition, two conditions in which participants physically texted a message they received while driving and while not driving, and two conditions in which participants verbally responded to a message that they received while driving and also while not driving. The voice response conditions were captured by a voice recorder to track accuracy. The participants were instructed to follow the vehicle in front of them at a safe distance. They were instructed not to pass the vehicle, and to brake when the lead vehicle did. The participants were instructed to inform the researcher of feelings of sickness caused by the simulator.

Materials

Materials used were a low-fidelity driving simulator (PlayStation steering wheel and pedals), a voice recorder, two laptops (one for the surveys given at the beginning and the end of the experiment, and one for the alert notifying the participant of a new text message), a fan, a flat screen TV, and an Android touch screen phone. An app was also used to generate "messages" and send them to participants.

Results

Participants were asked to rate the perceived risk associated with texting and driving both before (M = 4.48, SD = .61) and after (M = 4.54, SD = .83) completing the experiments. The results show that the ratings of perceived risk did not change (t (32) = -.403, p = .690). Figure 1 depicts the results broken down by gender. The results hint that women may have perceived the risk of texting and driving to be greater after participating in the experiment (M = 4.5 versus M = 4.63), whereas males may perceive it to be lower (M = 4.44 versus M = 4.33). Statistical analyses on the data were not performed due to the unequal representation of males (N = -9) and females (N = 24) in the study. A future study is planned to determine whether these results can be replicated. Data for self-reported accidents reveal that women reported more accidents than men (women = .29, men = 0.0), but there were no differences in the number of self-reported traffic citations (F = .21 versus M = .22).
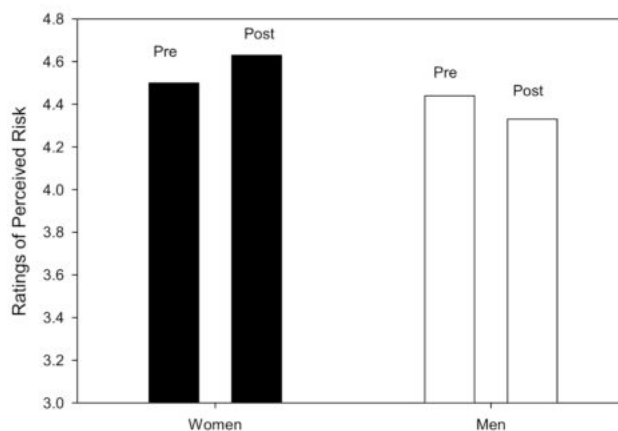

Figure 1. Pre and post-test rating of perceived risk for women and men.

A one-way ANOVA was conducted in order to evaluate the effects of task on brake reaction time. A significant difference was found between brake reaction time for the drive-only condition (M = 1.5 SD = .57) and drive manual-texting condition (M = 1.73, SD = .48, t (32) = -2.279, p = .030). The drive only condition and drive while verbally texting (M = 1.65, SD = .46) conditions did not differ significantly (t (32) = -1.56, p = .128). The manual texting and verbal texting conditions did not differ (t (32) = -1.28, p = .208).
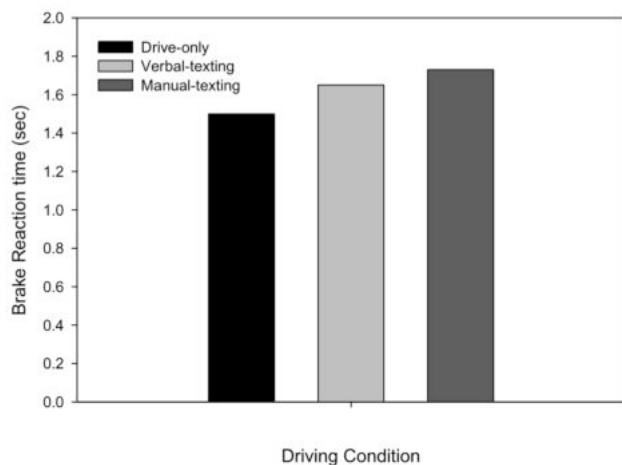

Figure 2. Brake reaction time by driving condition.

Correlation tests were performed between age and brake reaction times separately for each of the conditions. None of the correlations were significant. The results could possibly be due to the limited age range of the participants (age range = 18 - 29 yrs., M = 21.3, SD = 3.38).

Discussion

The purpose of this study was to investigate whether gender and age moderate the effects of secondary task distraction on driving performance. Studying gender and the types of distractions that complicate driving is important because it could change the way people view the dangers of distracted driving. Although society is well aware of the risk associated with distracted driving, individuals still convince themselves that they are always in control. Knowing how gender and age moderate the effects of distraction is important for informing training programs and public policy, and reducing the number of fatalities and car accidents. Distracted driving is

dangerous and should be handled as such. This study could help advocate for stricter distracted driving laws. Driving laws against texting and driving have been proven to reduce accidents significantly.

The results of the study suggest that participants may respond more slowly (particularly in the manual response condition in relation to the drive only condition; interestingly, the results also offer some evidence that women were slower than men by 200 milliseconds). Future research should investigate whether this is the case. Mean reaction times for women were longer in the two texting conditions (i.e., manual and verbally responding) compared to men. A reason for these results could be the way participants were recruited.

Interestingly, it was found that men reported a higher number of accidents whereas women reported a higher number of citations. The former result is consistent with accident data, which indicate that men have more accidents than women (Evans, 2004). These results suggest that it does not necessarily follow that individuals with a higher number of citations will also have more accidents.

It is not clear how to interpret the data on risk perception. The means for this comparison show that women perceived a higher risk before the conditions and an even higher risk after the conditions. Interestingly men perceived a lower risk than women before the conditions and an even lower risk than their initial perception after the conditions. More conclusive evidence of gender differences in risk perception is required from further investigation.

Limitations

There are a number of limitations to this study. Due to the unequal number of male and female participants, researchers could not test the effects of gender. The gender difference may reflect a growing imbalance in the representation of males and females majoring in psychology. Our participants were recruited using the Wichita State University SONA system, which allows psychology students to sign up for studies. A majority of the psychology student population is female. The study could be improved by recruiting equal numbers of males and females.

Unexpectedly, we found that the text application being used for the experiment had a different type of

touch keyboard than any of the participants currently use. This could be the cause of their inability to respond quickly and efficiently to the text messages. Having a variety of phones for the participants to choose from could allow for more accurate results. Also, the driving simulator was more sensitive compared to a normal vehicle.

Conclusion

In conclusion, there are many different factors that contribute to distracted driving. Factors, such as environment, age and gender can play a role in how dangerous it is for an individual to text and drive. Acts that seem normal to individuals can actually be putting them in hazardous situations without the driver even realizing it.

Texting and driving is a very dangerous act. Unfortunately, it will never cease to exist. There is no way to completely eliminate this behavior. No matter the amount of upgrades to texting technology, it will never be as safe as society would like. Therefore, the amount of fatalities may decrease with new technology, but deaths will still occur. The purpose of this experiment was to investigate how gender and age impact reaction time while texting and driving. This is important because it will help keep individuals aware of the risk associated with texting and driving.

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Youth Sport Administrators' Perceptions and Knowledge of Organizational Policies on Child Maltreatment
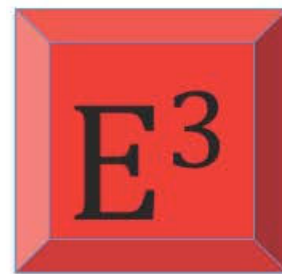
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Abstract

Youth Sports is one of the largest segments of the sport industry, generating over $5 billion annually (Wagner et al., 2010). Each year, 30 to 40 million children participate in a variety of programs in the United States that are offered by private, public, and non-profit organizations (Wagner et al., 2010). Of particular concern for youth sport administrators is the abuse and maltreatment of participants in their programs. High-profile cases, such as, the Jerry Sandusky/Penn State University scandal, has brought attention to this issue (Freeh, 2012). It is imperative that administrators of youth sport organizations implement measures to protect the children they serve (Kerr & Sterling, 2008). The purpose of this research was to determine the perception of youth sport administrators' awareness of the organization's policies relating to the signs and symptoms of child abuse, and reporting procedures concerning such abuse. A purposive sampling of 217 practitioners identified through Internet research from public recreation departments, non-profit organizations, and for-profit businesses for children were contacted; 108 of those selected participated. The limitations were that the participants were from one Midwestern state and second, rated their own assessment. As nearly a third of respondents were unsure or did not believe they should be mandated reporters, attitudes toward this topic warrants further investigation.

Introduction

Youth sports are one of the largest segments of the sport industry, generating over $5 billion annually (Wagner et al., 2010). Each year, 30 to 40 million children participate in a variety of programs throughout the United States offered by private, public, and non-profit organizations (Wagner et al., 2010). The benefits of participating in physical activity and sports continue to be emphasized at local and national levels, as they contribute to the overall development of physical, cognitive, social, and affective domains; and promote active, positive lifestyles for those who participate (Bailey, 2006). In the United States there has been particular emphasis on programs promoting wellness and fitness, due to the growing concern of childhood obesity (Hofferth et al., 2005). There is also a growing demand for youth sport programs that provide advanced instruction and training, particularly in team sports, in which nearly 70% of children between the ages of 6 and 17 participate (Sport & Fitness Industry

Association, 2011).

Because of the significant child population, it is paramount for sport organizations to implement measures for child protection (Kerr & Sterling, 2008). Of particular concern for youth sport administrators is the abuse and maltreatment of participants in their sport programs. High profile cases have brought attention to this issue, particularly in youth sport and recreation settings. KGW News (Oregon City) reported in 2011 that a soccer coach, Parrish Leland Chang Sr., had been charged with multiple counts of child porn, encouraging child sex abuse after police seized his personal computer and found over 100 pornographic videos of children. Documents on his home computer contained pictures, including one titled, "11-year-old Girl Raped" (KGW, 2011). Closer to the Midwest, another crime against a child was reported in Garland, Texas. On September 24, 2012, a soccer coach was arrested for raping a 10-year-old soccer player. Three more possible victims talked to police, who believed that even more victims were avoiding coming forward due to their immigration status (WFAA 8, ABC, 2012).

The most notable of these cases involved Gerald Sandusky, a former assistant football coach at Penn State University, who was found guilty of 45 counts of child sex abuse, with a number of those incidents having occurred in facilities on the Penn State campus. One of the key issues of the case was the failure of university leaders – the president, a senior vice president, the athletic director, and head football coach – to take appropriate action when allegations of abuse were brought to their attention (Freeh, 2012; McGregor, 2012). When the allegations became public, the Penn State Board of Trustees responded by firing the four leaders associated with the incident and calling for an internal investigation of the issue, which was led by former FBI director and Federal Judge Louis Freeh. The results of the investigation concluded that the four university leaders "failed to protect against a child sexual predator for over a decade," and that the former president "discouraged discussion and dissent" (Freeh, 2012, p. 14). The investigation also noted that the prominent leaders at Penn State demonstrated "total and consistent disregard…for the safety and welfare of Sandusky's child victims," and that those leaders were "unchecked by the Board of Trustees that did not perform its oversight duties" (Freeh, 2012, p. 15). In

addition, the investigation noted that the Board "failed in its duties to oversee the president and senior university officials in 1998 and 2001 by not inquiring about important university matters and by not creating an environment where senior university officials felt accountable? (Freeh, 2012, p. 15). The report also noted that the Board of Trustees failed to have "regular reporting procedures or committee structures in place to ensure disclosure to the Board of major risks to the university" (Freeh, 2012, p. 16; McGregor, 2012).

All youth sport programs should have zero tolerance for any form of child abuse, whether it is emotional, physical, or sexual (Wurtele, 2012). If youth sport programs are to be successful, administrators and leaders must develop and implement policies and procedures that place the safety of their youth participants among their highest priorities, and create a culture of zero tolerance for any form of abusive behavior (Brackenridge, 2002; Wurtele, 2012). Because of their regular interaction with children, administrators of youth sport programs have opportunities to observe children for signs of abuse or neglect, and can be involved in the detection, treatment and prevention of child abuse. Reporting suspicions of abuse allows child protective authorities to become involved before a child is seriously injured (Wilson & Gettinger, 1989; Zellman, 1990).

Literature Review

Types of Child Abuse

Child abuse and maltreatment, defined as "volitional acts that result in or have the potential to result in physical injury and/or psychological harm" (Crooks & Wolfe, 2007, p. 3), has become a growing area of concern throughout the United States. While physical abuse is the most visible, other types of abuse, particularly sexual abuse and neglect, are also damaging to those who are exposed to maltreatment.

Physical abuse is non-accidental physical injury *(ranging from minor bruises to severe fractures or death)* as a result of punching, beating, kicking, biting, shaking, throwing, stabbing, chocking, hitting *(with a hand, stick, strap, or other object)*, burning or otherwise harming a child, that is inflicted by a parent, caregiver or other person who has responsibility for the child. Such injury is considered abuse regardless of whether the caregiver intended to hurt the child" (U.S.

Department of Health and Human Services, Children's Bureau, 2011). It may be the result of a deliberate attempt to hurt the child, but not always. It can also result from severe discipline, such as using a belt on a child, or physical punishment that is inappropriate to the child's age or physical condition (Smith & Segal, 2012).

Child neglect—a very common type of child abuse—is a pattern of failing to provide for a child's basic needs, whether they be physical, medical, educational, or emotional in nature (Smith & Segal, 2012). Child neglect is not always easy to identify. At times, a parent might become physically or mentally unable to administer proper care to a child. This may occur, for example, when a parent suffers a serious injury, untreated depression, or anxiety. Additionally, alcohol or drug abuse may seriously impair a caretaker's judgment and the ability to keep a child safe. Cultural values, the standards of care in the community, and poverty may also be contributing factors for neglect, indicating the family is in need of information or assistance. When a family fails to use information and resources, and the child's health or safety is at risk, then child welfare intervention may be required. Many states, however, provide an exception to the definition of neglect for parents who choose not to seek medical care for their children due to religious beliefs (What is child, 2008). Older children might not show outward signs of neglect, presenting a competent face to the outside world, and even taking on the role of the parent. Nonetheless, even under the surface, neglected children are lacking essential physical and emotional support (Kerr & Sterling, 2008; Smith & Segal, 2012).

Sexual abuse is defined as "the employment, use, persuasion, inducement, enticement, or coercion of any child to engage in, or assist any other person to engage in, any sexually explicit conduct or simulation of such conduct for the purpose of producing a visual depiction of such conduct; or the rape, and in cases of caretaker or inter-familial relationships, statutory rape, molestation, prostitution, or other form of sexual exploitation of children, or incest with children" (What is child, 2008). It's important to recognize that sexual abuse doesn't always involve body contact. Exposing a child to sexual situations or material is also considered to be sexually abusive, whether or not touching is involved (Kerr & Sterling, 2008; Smith & Segal, 2012).

Overview of Child Abuse Legislation

Federal Legislation on Child Abuse in the United States

Laws regarding the reporting of child abuse are intended to provide government agencies with the means to investigate allegations of child maltreatment. In the United States, responsibility for reporting suspected abuse initially fell on family members. It was the responsibility of parents to ensure their children were properly cared for (Persky, 2012). In the 1870s a case in New York City involving the abuse of a child by her stepmother brought attention to the plight of abused children and the need for outside intervention. In response to this case, the first organization in the world devoted to the protection of children from abuse, the New York Society for the Prevention of Cruelty to Children, was founded in 1875 (New York Society, 2012). The 1930s saw the establishment of a child welfare system by the federal government, reflecting a changing attitude toward the amount of acceptable government intervention for helping individuals in need. In one of the first scholarly articles to address the subject, Kempe et al., (1962) concluded that physicians were in a position to objectively identify and evaluate potential abuse in children, and that they have a duty and responsibility to ensure that such abuse is not permitted to happen again. In 1974, the Child Abuse Prevention and Treatment Ace (CAPTA) were enacted by Congress to provide federal funding to states that enacted mandatory reporting laws (About CAPTA, 2011). States that didn't comply or report abuse lost funding for prevention and education. With these funds states have set up their own public child welfare systems to investigate and respond to reports of abuse and take action on behalf of the victims if allegations are substantiated. The Adam Walsh Child Protection and Safety Act, signed into law in 2006, was aimed at protecting children from violent crime and sexual exploitation. This led to the formation of an online national sex offender registry and the enacting of harsher penalties for crimes against children (Wurtele, 2012). Internet crimes against children led to the passage of the Protect Our Children Act in 2008. The proposed "Protect our Kids Act of 2011," aims to reduce fatalities among children as the result of abuse and neglect (Wurtele, 2012).

State Legislation on the Reporting of Child Abuse

When the results of the Kemp et al. research became public, states took action to pass laws making child abuse a criminal act (Persky, 2012). Most state statues originally specified very few mandated reporters. Over time, many of those statues have been amended, broadening their definitions of mandated reporters to include teacher and childcare workers (McKinley, 2012; Persky, 2012). Each state determines what cases will be investigated and how authorities will respond based on the state's statutes and regulations (Persky, 2012; Wolfe, 2012). Each state's child abuse reporting law identifies individuals who are mandated by law to report suspected abuse. Along with doctors, teachers, and day care staff, many state statutes also identified counselors and law enforcement personnel as professionals who can provide insight into potential abuse (Persky, 2012). Some states mandate coaches to report suspected abuse, while others mandate parents to do so. In every state, anyone who is not mandated by law to report child abuse still has the option to report suspected maltreatment voluntarily. Additionally, each state permits voluntary reports to be made anonymously (Wolfe, 2012).

A number of states have addressed the reporting or communicating of suspected child abuse as a hierarchical responsibility. Pennsylvania, for example, amended its law to require the person with direct knowledge of the abuse to report "up" to their supervisor or director within his or her organization, rather than reporting the incident directly to the child welfare system. It is the organization administrator who them determines whether or not filing the report to the appropriate authorities is warranted (Wolfe, 2012). In Maryland, reports of potential abuse are screened before a formal investigation determines abuse has occurred, then the case is referred to a child advocacy center (Persky, 2012).

Recent Changes in Child Abuse Reporting

In response to incidents such as the one at Penn State, numerous sport organizations throughout the U.S. have enacted measure to train the administrators of their youth programs to identify and address issues related to child abuse, with the most notable issue involving the reporting of suspected child abuse.

Each year an estimated 3.3 million reports of child abuse are made in the United States, involving over six million children (due to reports including multiple children), according to the U.S. Department of Health and Human Services (2011). As of September 2012, 107 bills in 30 states and the District of Columbia have been introduced in the legislative session on the reporting of suspected child abuse and neglect, with 10 of these states enacting legislation (National Conference of State Legislatures, 2012). Those pushing to clarify and broaden current statues hope to prevent a recurrence of everything that went wrong at Penn State (McKinley, 2012; Persky, 2012; Wolfe, 2012). Some universities and colleges have initiated changes that focus on expanding who is mandated to report suspected child abuse and neglect. The University of Maryland established new procedures requiring any employee to provide both an oral and written report within 48 hours of witnessing possible child abuse or neglect to the local police department or to a local office of social services. It requires the university president or someone designated by the president to received such reports. Failure to abide by the reporting policy could result in termination (Ujifusa, 2012). At Duke University, a new policy was established which requires everyone on campus to immediately report suspected abuse of minors to Duke police and the program director, and also requires background checks and special training for everyone working with minors, even those not employed by Duke (Moore, 2012).

Additional efforts are aimed at increasing public awareness of child abuse and the need to report abuse. Initiatives to expand and improve training for both mandated reporters and the general public on identifying and reporting potential child abuse was implemented through the state of Pennsylvania *Task Force on Child Protection*, which was recently commissioned by the state legislature to develop a report on ways to improve child abuse reporting, training, laws and policies and procedures (Wolfe, 2012). After Robert Dodd, former Amateur Athletic Union (AAU) President was accused of child molestation, the AAU examined the need for establishing two different task forces to review the organizations' current policies related to the protection of their athletes, particularly children (Braconnier, 2011). The National Coalition to Prevent Child Sexual Abuse and Exploitation (2012)

has published a national plan aimed at enhancing resources and increasing awareness of child sexual abuse, and offers suggestions as to how these goals may be accomplished.

Child Abuse Policies in Youth Sport Organizations

In order to ensure the safety of the children who participate in their programs, youth sport organizations need to implement policies that reflect the organization's intolerance for any form of abuse. All adults who work with children at all levels in the workplace, whether paid or unpaid, must make the effort to create a culture of zero tolerance for any form of abuse (Wurtele, 2012). One of the most common strategies implemented by youth sport organizations involves conducting criminal background checks on all employees and volunteers. These are done to identify individuals who have a history of criminal misconduct, potentially decreasing the risk for child abuse (National Alliance for Youth Sports, 2012; Wurtele, 2012). Some agencies have created environments that make it difficult for abuse to occur, by minimizing opportunities for staff to be alone with youth, establishing separate accommodations for youth and adults, and limiting contact outside the organization, whether in person or through social networking sites (Wurtele, 2012; Wurtele & Kenny, 2012). Enhanced supervision and monitoring of employees during staff-youth interactions enables organizations to identify potential issues and possibly prevent the abuse of a minor (Preventing Child Abuse, 2012; Wurtele, 2012: Wurtele & Kenny, 2012).

Educating staff and volunteers is paramount in preventing and identifying abuse in children. In-service training enhances the awareness of an organization's commitment to youth safety and intolerance of abusive conduct (Wurtele, 2012). All staff and volunteers who work with children need to understand their ethical and legal duty to report any reasonable suspicions of abuse to a designated state agency or law enforcement (Wurtele, 2012; Wurtele & Kenny, 2012). Some youth sport organizations have developed comprehensive strategies to educate their staff about ways to prevent and report child abuse. Online training programs such as Darkness to Light's (2004) *Stewards of Children* and Positive Coaches Alliance and Kidpower's (2012) two-part webinar series on child abuse prevention have served as

effective, low-cost methods of teaching individuals on the importance of reporting and preventing abuse.

Issues with the Implementation of Policies Addressing Abuse

Studies conducted on child protection in sport have indicated a number of issues appear to hamper the implementation of policies and other measures geared toward protecting children from abusive behaviors, such as a lack of resources, fear, and administrative difficulties (Parent & Demers, 2011). Research has also shown a policy void relating to child protection between sport federations and affiliated local clubs, indicating measures implemented by higher-level organizations rarely reach their lower-lever counterparts (Brackenridge 2002, Brackenridge et al. 2004; Parent & Demers, 2011). Administrators of programs, though well-versed in their child protection policies, often encounter numerous administrative problems in carrying out said policies, such as long delays in criminal background checks or problems with regard to the sharing of information about offending coaches among sport organizations (Brackenridge et al., 2004). Some organizations fail to conduct proper screening of employees and volunteers because it simply costs too much, or because of the perception by administrators that screenings aren't particularly useful (Wurtle, 2012). Other agencies fail to address allegations of abuse for fear of losing successful coaches and deny the existence of abuse in their organizations (Malkin et al., 2000). Similarly, agency administrators also express concerns that an increased emphasis on prevention programs will arouse suspicions that abuse is taking place within their organizations (Parent & Demers, 2011). These studies have mostly been conducted in a European context, and current knowledge on the subject, particularly in the United States, remains scant (Brackenridge, 2002; Parent & Demers, 2011; Wurtele, 2012). The literature reviewed supports our recommendation for more research of the policies of sport recreational facilities concerning all staff working with youth. Finding gaps in training and reporting child abuse are imperative for the protection of youth (Kerr & Sterling, 2008).

The purpose of this study was to determine the perceptions of youth sport administrators' awareness of their organizations' policies relating to signs and symptoms of child abuse, and reporting procedures concerning such abuse.

This study seeks to investigate youth sport administrators' self-reported knowledge of the signs and symptoms of child maltreatment, reporting procedures, legal issues surrounding child abuse, and their attitudes toward their organizations' policies pertaining to child abuse.

The following research questions will guide the study:

1. Are youth sport administrators aware of the signs of child abuse?
2. Are youth sport administrators aware of the reporting procedures for child abuse?
3. Are youth sport administrators aware of their organizations' policies and procedures regarding child abuse?
4. Do administrators of youth sport programs understand the legal issues surrounding child abuse as it pertains to their position?
5. Are youth sport administrators comfortable with the training they receive from their organization regarding the reporting of child abuse?

Method

Participants

Youth sport administrators from public recreation departments, non-profit organizations, and for-profit businesses in one Midwestern state that offer sport and recreation programs to children 17 years of age and younger were targeted by the researcher. For the purpose of this study, a youth sport administrator is defined as one who is responsible for programming, implementation, and administration of sport and recreation programs and activities for children 17 years of age and younger. A purposive sampling of 217 practitioners was identified as potential subjects through an Internet search of organizations with youth sport programs.

Instrument

The Administrators and Child Abuse Questionnaire (ACAQ) is an adaptation of the Educators and Child Abuse Questionnaire developed by Kenney (2001). The first portion contains 12 statements related to (a) competence in identifying and assessing various types of child abuse, (b) knowledge of reporting procedures, and (c) attitudes toward their organization's policies and procedures regarding child abuse. Each item is followed by five levels of

agreement. Each subject was asked to select, for each descriptive scale, the rating that best described their feelings toward the item using the following scale: 1 = strongly disagree; 2 = somewhat disagree; 3 = neither agree nor disagree; 4 = somewhat agree; 5 = strongly agree. Subjects were asked to read each statement and place a checkmark in the appropriate box on their response sheet.

The second portion of the survey, requests specific demographic information, such as age, gender, ethnic background, experience in youth sport administration, years in their current position, and educational background. Face validity of the instrument was established through an extensive review of pertinent literature, and evaluated by experts in the field of sport management and survey research.

Procedure

To collect data, a link to the survey was e-mailed to all targeted youth sport administrators. The e-mail introduced the researcher and informed the reader of the researcher's intention to conduct a survey of their attitudes on child abuse training and policies within their organizations. The purpose of the study was explained as well. The e-mail requested their assistance by completing the survey. Youth sport administrators under the age of 18 were advised not to participate in order to avoid accessing a "vulnerable" population. Those who chose to participate were asked to click on a link that provided access to the survey instrument, which would take approximately two minutes to complete. The Institutional Review Board for the Protection of Human Subjects at Wichita State University provided approval for the study. The survey served as the only method of collecting data. Two follow-up e-mails were distributed to remind youth sport administrators of the survey. Data from completed surveys were tabulated by the survey website, with results accessible only to the primary investigator.

After data collection, the final sample included over 100 usable responses (n=108).

Results

Of the 217 surveys sent, 108 were completed, for a response rate of 49%. From that sample of respondents, 55% were male, and 90% were

Caucasian. Of the three types of agencies represented: 59% worked for non-profit organizations, 29% for public, and 12% were employed by private agencies. The respondents represented a wide range of experience working with their current organization, but the majority (60%) had been with their agency four years or longer. As for experience working in youth sport settings in general, 80% of the respondents had at least four years or more. Over half (51%) of the respondents possessed a bachelor's degree, while 18% either had some post-graduate education or earned a graduate degree. Univariate descriptive statistics show that 65 respondents indicated they have never made a report of suspected child abuse.

In the 12 statements from the Administrators and Child Abuse Questionnaire (ACAQ), an overwhelming majority of respondents felt that child abuse is a serious problem in our society, but most (64%) believed that child abuse is not a problem in their youth programs (see Table 1). Eighty-one percent indicated they were aware of the policies and procedures of their organization that pertain to the reporting of child abuse and the majority (83%) felt their administration would support them if they made a report of suspected child abuse. Most of the respondents (80%) agreed that as administrators of youth sport programs, they are obligated to report suspected child abuse. While 64% indicated disagreement with the statement that youth sport administrators should not be mandated to report abuse, 21% were unsure, and 15% agreed or strongly agreed with the statement. The majority of administrators indicated confidence in identifying the different types of abuse:

- 71% indicated they were aware of the signs for neglect,
- 60% were aware of the signs for child sexual abuse, and
- 80% agreed or strongly agreed they could identify signs of physical abuse.

In terms of their training, 41% of respondents were unsure if their agency provided adequate training on identifying and reporting child abuse, while 24% felt their organizations didn't provide enough training in this area. Along these lines, 34% indicated that most of their training in dealing with child abuse issues came from outside their current place of employment, while 31% stated their current agency provided them with the majority of their knowledge on the topic. Fifty-eight percent indicated their current organization had policies in place that address how to deal with child abuse, while 29% were unsure or unaware if their organization had such policies, and 13% disagreed that their agencies had these types of policies in place.

Discussion

Though the incident at Penn State has brought the issue of administrative preparation in the reporting of child abuse to the forefront of national consciousness, the results of this study indicate that administrators of youth sport programs in this region, while they believe child abuse is a serious problem, don't feel it's an issue in their respective organizations. This is reflected in their confidence with their knowledge of the signs of different types of abuse, particularly neglect and physical abuse. While nearly two-thirds of respondents indicated they were aware of the signs of sexual abuse, it's important to note that the remaining third was not confident with their abilities to detect it. Though neglect is considered the most difficult form of abuse to identify (What is child, 2008), these results indicate youth sport organizations may need to provide their administrators with better training in regards to identifying potential victims of sexual abuse.

One of the main findings indicated in the Freeh Report on the Penn State scandal was that the administration failed to have appropriate policies and procedures in place for the reporting of suspected child abuse, and those in positions of leadership failed to create an environment that was supportive of such action (Freeh, 2012). The results of this study show this is not the case with these youth sport administrators, as over three-fourths of the respondents indicated that they are aware of their organization's policies on reporting child abuse and believe they would receive support from their superiors if they followed through with a report of suspected abuse. This reflects positively on the preparation and awareness of child maltreatment in these organizations, but as the safety of children is the prime directive for every youth sport organization, it appears that more needs to be done to ensure all youth sport administrators are cognizant of their organizations' policies on reporting suspected abuse and are confident in executing them.

Table 1: Percentages of responses to 12 statements of the ACAQ (N=108)				
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Child abuse is a serious problem in our society				
40.8	52.6	1.3	2.6	2.6
Child abuse is a serious problem in my youth programs				
0.0	5.3	30.3	40.8	23.7
I am aware of my organization's policies and procedures for child abuse reporting				
29.3	52.0	9.3	8.0	1.3
I feel the administration would support me if I made a child abuse report				
42.1	40.8	14.5	1.3	1.3
As a youth sport administrator, I have an obligation to report suspected child abuse				
45.3	34.7	16.0	1.3	2.7
Administrators of youth sports programs should NOT be mandated to report child abuse				
6.6	7.9	20.1	31.6	32.9
I am aware of the signs of child neglect				
15.8	55.3	22.4	5.3	1.3
I am aware of the signs of child sexual abuse				
10.5	50.0	30.3	7.9	1.3
I am aware of the signs of child physical abuse				
22.4	57.9	17.1	1.3	1.3
My organization provides adequate training to all employees who work with children on how to identify and report child abuse				
9.3	25.3	41.3	20.0	4.0
Most of what I know about dealing with child abuse came from training I received through my current organization				
3.9	27.6	28.9	34.2	5.3
Our organization has policies in place that address how to deal with issues related to child abuse				
15.8	42.1	28.9	10.5	2.6

Most respondents (two-thirds) to the survey indicated, though not specifically required by state law, youth sport administrators should be mandated to report incidents of suspected child abuse and maltreatment. As many as one-third of the respondents were unsure or did not believe they should be mandated reporters, attitudes toward this topic warrant further exploration.

While the state in which this study was conducted had over 64,000 reported incidents of child abuse and neglect in fiscal year 2012 (Kansas Children's Service League, 2012), the overwhelming majority of youth sport administrators indicated they have never made a report of suspected maltreatment of a child. As most youth programs are located in highly populated urban areas, it is possible that some respondents may have encountered victims in their programs but were not able to identify them.

Limitations

The sample of participants for this study all work for organizations within one Mid-western state. While their attitudes may be similar to other youth sport administrators from the region, the findings from this study are limited to one geographic area. Second, the respondents rated their own assessment of their knowledge and abilities rather than being tested in these areas, so their actual knowledge regarding their ability to identify different types of abuse and awareness of their organizations' policies on child maltreatment are unknown. Third, though the majority of respondents indicated they have never filed a report of suspected maltreatment, there is no confirmation of the validity of the youth sport administrators who indicated they have reported suspected abuse, as the method for reporting protects the confidentiality of the abuse reporter.

Recommendations for further study

It is recommended that sport agencies that provide programs to children have child abuse reporting policies in place that employees can access and implement with certainty. Youth sport organizations

can enhance the awareness and knowledge of their employees by providing appropriate training and support (Kenny, 2004; Kerr & Sterling, 2008). Further research is needed to assess the readiness of youth sport administrators to address suspected abuse of program participants. Additional studies should further address potential differences based on ethnicity and geography, as well as policy differences and awareness between types of programs (public, private, non-profit). In addition, expanding the pool of research to include all employees and volunteers who have contact with children (instructors, coaches, bus drivers, etc.) in addition to those who administrate would provide greater insight into the issue of child abuse in the U.S. (Brackenridge, 2002; Wurtele, 2012).

Conclusion

The purpose of this research was to identify the perceptions of youth sport administrators in a mid-western town in Kansas concerning child abuse and how organizations prepare them for reporting such incidences. It appears that many Kansas youth sport administrators believe child abuse is a critical issue in society, even if not identified explicitly as a problem in their programs. Recently, there have been numerous, high-profile scandals involving children and sport organizations that have helped to redirect the focus of child abuse not only in society, but also the role of sport administrators in this process, (Braconnier, 2011; Churchmach, 2012; McGregor, 2012). What is still unclear is how organizations are preparing youth sport administrators to deal with the possibility of child abuse or maltreatment of youth participants and how they should handle it. There is not a clear consensus or agreement on how policies and procedures or training should be handled. This could be due to the low report rates of child abuse by the sample.

In the state of Kansas, health-care professionals, educators, and emergency response personnel are mandated by law to report any incidents or suspicion of child abuse to the authorities (Kansas Children's Service League, 2012). Since youth sport administrators' frequently interact with children under the age of 17, and there are no state laws that mandate the reporting of such incidents, it is important to understand the perceptions and knowledge of child maltreatment of these professionals as it relates to the policies of the organizations of their employment.

It is recommended that youth sport organizations fully develop clearly articulated organizational policies regarding child abuse or maltreatment. In order to develop the policies, it is recommended that there be child abuse training sessions conducted in youth sport organizations by licensed personnel. Because of the cost associated with such training sessions, the recommendation is that youth sport organizations proactively contact the appropriate state or county agencies for these training sessions. As child abuse entails more than just physical abuse (Smith & Segal, 2012), training sessions can be scheduled on a regular basis, i.e. monthly, quarterly or annually and these trainings can cover a wide range of abuse-related topics.

State law does not currently mandate youth sport administrators to report suspicions of child abuse in Kansas. Therefore, the onus is now placed upon both youth sport organizations and the administrators operating these programs to proactively educate themselves regarding the issue. Youth sport organizations should also mandate either a code of conduct for administrators explicitly articulating a stance on child abuse reporting, and this should be incorporated into an employee manual. The large number of survey respondents selecting "neutral" on the items associated with organizational policies or training regarding child abuse could easily be interpreted as a need for organizations to clearly delineate not only a stance on reporting child abuse, but also increased training opportunities showing employees how to recognize and properly report child abuse or maltreatment.

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Nest Success of the Blue-gray Gnatcatcher: Relevance for Understanding Population Declines of Neotropical Migratory Songbirds
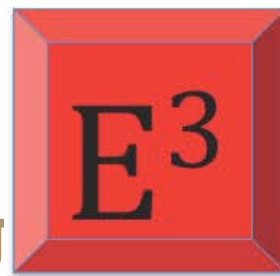
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Abstract

The Blue-gray Gnatcatcher is a Neotropical migratory songbird with stable population rates and a conservation status of least concern. The Gnatcatcher can serve as a model species to help researchers determine what steps need to be taken to protect Neotropical songbirds suffering from population decline. For our study, we monitored the nest success of the Gnatcatcher because it reflects an adult survival rate similar to the Cerulean Warbler, a vulnerable Neotropical migrant suffering population decline. The actual cause of songbird decline is uncertain, though habitat loss and nest predation are considered to be primary concerns. We hypothesized that if the Warbler's reproduction rates are found to be lower than the Gnatcatcher's, the species population may be declining as a result of low reproduction. This would support the theory that conservation efforts should focus on the breeding grounds of the Cerulean Warbler, rather than the wintering grounds. Literature concerning both species of songbird was reviewed and taken into consideration in addition to Cerulean Warbler nest success rates from a previous study in Michigan. From late April through late June, we plotted and monitored Gnatcatcher nests at the Wichita State University Field Station in the Ninnescah Reserve. A total of six nests were found, with only two surviving through the season, a lower number than those found in previous years of the study. After analyzing the data collected this year and during previous years of the Gnatcatcher study, our hypothesis on the breeding ground condition being the cause of Cerulean Warbler decline was not supported. Previous years of low reproductive success and difficult environmental conditions at the study site may have influenced our results.

Introduction

Globally, vertebrates are suffering a decline in biodiversity. Higher species diversity allows for higher trait availability, which enhances a species' ability to adapt. The ability to adapt with habitat succession affords stability and better chances of survival. Generalized (adaptable) species are more tolerant of environmental changes and can utilize more territories. Specialized (less adaptable) species can occupy limited home ranges. When habitats are destroyed, the habitable range for wildlife shrinks. Already restricted by specific niche requirements, specialized species are forced to share smaller niches that contain limited resources. Generalized species are less vulnerable to environmental disturbances and can utilize a larger variety of resources (Bolger, Patten, & Bostock, 2005; Coppedge, Engle, Masters, & Gregory, 2001). The decreased population of specialists will restrict gene flow and hinder genetic diversity, which may further weaken the species and potentially result in extinction.

The biodiversity of songbirds is declining as a result of changes to their habitat. The actual cause of songbird decline is uncertain, though habitat loss and nest predation are considered primary concerns (Rogers, 2011; Svagelj, 2009). There are two central theories attempting to explain the decline of songbirds: deterioration of songbird breeding grounds and habitat loss, and degradation of songbird wintering grounds. The hypothesis that deteriorating breeding grounds are the cause of songbird declines focuses on the condition of the warblers' breeding grounds, and would investigate how many offspring are successfully fledged, and how environmental factors in the breeding grounds influence that number. This would concern the rate of offspring successfully fledged. The second hypothesis claims habitat loss and degradation of the wintering grounds is the cause of population decline. This hypothesis focuses on adult survival rate rather than the rate of offspring fledged.

The Cerulean Warbler (*Dendroica cerulean*) is a migratory songbird that is suffering one of the greatest population declines of Nearctic-Neotropical migrant songbirds (Buehler et al., 2008; Rogers, 2006). This warbler has a current conservation status of vulnerable, and may become endangered if the population does not stabilize (IUCN Red List of Threatened Species, 2013). For the population to stabilize, offspring must be fledged at a rate equal to the lifelong mortality rate. If the rate of birds fledged from the nests is lower than the mortality rate, the population will continue to decline (Hallworth, Ueland, Anderson, Lambert, & Reitsma, 2008).

For our study, we tested the breeding ground hypothesis. To study the influence of reproductive success on the Cerulean Warbler population, the Blue-gray Gnatcatcher (*Polioptila caerulea*) will be used as a model species. The Blue-gray Gnatcatcher is a Neotropical migratory bird that does not appear to be suffering a decline in population. During the study, we monitored Blue-gray Gnatcatcher nests weekly from mid-April to the end of June at the Wichita State University Field Station at the Ninnescah Reserve. If the warbler's rate of reproduction from the previous study by Buehler et al. (2008) is less than what we gathered for the Gnatcatcher, the Cerulean Warbler may possibly be declining as a result of lowered reproduction. This will indicate that conservation should focus on the breeding grounds of the warbler, not the wintering grounds.

Previous Research

Breeding Ground Hypothesis

Habitat heavily influences distribution, abundance and reproductive success of birds, which clues researchers where to begin searching for the problem. Many migratory songbirds exercise high breeding site fidelity throughout their lives (Hallworth, Ueland, et al., 2008). Studies on North American migratory warblers show how particular characteristics were favored for territory selection, such as edge effects, stand structure, vegetation, social and demographic features and high song perch availability. By repairing and preserving quality breeding habitats, site fidelity would likely be higher, enabling males to secure more productive territory for future breeding seasons. Hallworth found that a significant number of returning birds arrived earlier in the season than first year migrators to claim territory. Returning males were often able to better locate ideal territory and secure more suitable breeding sites, making the returning male more attractive to females. Breeding ground fidelity has been found to be significantly higher for breeding grounds that offered more concealed, mature plant species, rather than thinner,

younger vegetation, even when both sites allowed successful pairing and successful fledging (Hallworth, Ueland, et al., 2008). The preferred, mature sites fledged more birds than the younger, less dense sites. For Hallworth et al., the preferred breeding sites happened to be Red Maple swamps in New Hampshire (2008). Red Maples were favored by the Canada Warbler and happen to be of low commercial use. The researchers reason that if forest managers prevent clear-cutting Red Maples and the draining of area swamps, this species would likely fledge more offspring and potentially stabilize the population.

Less predictable climatic events leave breeding pairs of songbirds more vulnerable to ecological extremes. The focus of Bolger, Petten & Bostock's study was to evaluate the reproductive failure in birds due to extreme climatic events. One year of the study (2002) took place during the lowest rainfall recorded in a 150-year climate record. This study took the bottom-up and top-down limitations into consideration for the Rufous-crowned Sparrow (*Aimophila ruficeps*), hypothesizing that the species population is limited by food availability (2005). This sparrow is categorized as least concerned; however, the species has been suffering population decline in recent years (BirdLife, 2012). Limitations on the Rufous-crowned Sparrow appear to be bottom up in years of low precipitation, but top-down limiting in years of average and high precipitation. Though lower precipitation put the nesting birds at higher risk of failure, high levels of rainfall appeared to encourage predation, by providing the predator with better health and abundance (Morrison & Bolger 2002). Other residential birds included in the study were the wrentit (*Chamaea fasciata*), spotted towhee (*Pipilo maculatus*) and California towhee (*Melozone crissalis*). During the first year of the study (2001), 88% of the bird pairs attempted to support at least one nest during the breeding season. During the record low drought, only 6.7% of the mating pairs in all four species attempted to build at least one nest. Out of the 6.7% of pairs that attempted to build a nest, only 1.8% of those pairs fledged offspring, in contrast to the year before, where 1.36% to 3.14% of pairs fledged offspring. Many pairs in 2002 only established territories and did not build nests (Bolger et al., 2005). Previous studies of the Rufous-crowned Sparrow show a delayed correlation with the annual rainfall (Morrison & Bolger, 2002). The rate of reproduction correlates with the population of arthropod availability, where the population of arthropods significantly dropped in 2002 (Bolger et al., 2005). In this study, all four species of birds appeared to be affected by the extremely low precipitation. Though food availability has received less focus, it can also be argued that water availability in general improves the likelihood of reproduction, enabling cooling off, preferred vegetation growth and egg production itself. The Rufous-crowned Sparrow's breeding productivity reveals a steeper linear correlation between annual rainfall and breeding productivity over a five-year investigation (Bolger et al., 2005). The Discussion section of the article *Avian reproductive failure in response to an extreme climatic event* hypothesized that arid and semi-arid regions tend to host more precipitant-dependent birds, writing that other studies that reported almost complete reproductive failure were only recorded on arid study sites (Bolger et al., 2005).

Birds have slowly evolved over centuries to survive climatic and environmental changes; however, human disturbance has accelerated succession past the natural speed of evolutionary adaptations. Changes as slight as the introduction of new species of flora to an established breeding site can place pressure on local and migratory species. Human settlement, for example, has allowed nonnative plants to invade the grasslands. The grasslands have seen significant population change in both plant and animal species as settlers altered them for agriculture and cattle grazing. Farmers planted woody trees to prevent soil erosion, woody plants whose seeds were later spread by cattle as they overgrazed the native prairie vegetation. These new farming practices prevented the natural prairie fires. Without fire to eliminate the growth, woody plants were able to mature and continue to spread across the prairie. Woody plants and trees were then able to out-compete the natural flora. Even in the restored prairie areas, woody trees still grow. For generalist species, the new woody trees offered more resource availability. More specialized species were hindered by the new vegetation. Many migratory birds as well as prairie natives are specialists that require the specific environment of the native grasslands. Water availability is limited in grasslands, because the areas often experience droughts that limit bird community size and diversity (Coppedge et al., 2001). Some declining species are able to survive in areas with large native grassland cores that are less affected by woody plant invasion. Woody plants place

these more sensitive species at risk for predation. Studies have found that rates of parasitism and predation increase near woodland edges (Coppedge et al., 2001). With the remaining native grassland ranges becoming smaller and thinner, specialist species are more vulnerable than ever before.

As the human population continues to expand, more land is being cleared to build housing and plant food crops. With smaller territory ranges available, migratory birds are forced to claim risky, poor quality breeding grounds. Using suitable breeding grounds during the study, Buehler focused on the effects of habitat quality on fledgling success rather than the range of availability. Buehler mentions in *Avian reproductive failure in response to an extreme climatic event* that Ceruleans travel longer than most other migratory birds, which may increase the probability that the birds never reach the breeding ground (Buehler et al., 2008). Of the five locations considered in the article, Mississippi Alluvial Valley (MAV), Indiana and Michigan were considered sinks, while Ontario and Tennessee appeared able to support stable Cerulean populations. MAV, Indiana and Michigan sites experienced high nest predation and nest parasitism during the study. One quarter of the Michigan site nest failures was caused by cowbird parasitism, likely a result of the increased woodland cover (Buehler et al., 2008). Out of all the sites, Mid-western populations in agriculture-dominated areas were the only ones unable to stabilize the Cerulean population during all the monitored years.

One of the greatest threats to nest success is predation and brood parasitism. The effects of nest predation and brood parasitism associated with the alteration of the Cerulean Warbler's breeding grounds required more investigation. In southern Michigan, Rogers studied nest success of the Cerulean Warbler at two different forest sites: Fort Custer United States Army Michigan National Guard Reservation (FTCU) and Barry State Game Area (BSGA). Both sites hosted large, mature trees with open understories and occasional spacing among the trees. These sites were chosen in part because the Cerulean Warbler has been slowly expanding its breeding ranges north. With more data regarding nest success for the Cerulean in the northern boarders of the breeding grounds, researchers can look for a pattern of improved nesting locations. At the FTCU site, more nests were built in trees found near unpaved gravel

roads. At BSGA, only one nest was found near a gravel road, whereas the other nests were near natural forest openings. In 2004, signs of re-nesting were only found at FTCU. In 2005, none were confirmed at BSGA. For the FTCU site three nests failed due to brood parasitism, two failed due to exposure after heavy rain and the nest branch breaking off due to high wind, and seven failed due to nest predation. These were the only 12 nests where cause of failure could be determined. The rate of nest success for the FTCU site was only 52%, so these failures are only a small sample of the casualties. Brown-headed Cowbirds, common nest parasites, were often seen throughout the site. Nest predators, such as the eastern fox squirrels and eastern chipmunks, were found over ten meters up in the trees at the BSGA site (Rogers, 2006). Cerulean nests at the FTCU and BSGA sites were not largely affected by cowbirds during the birds' short breeding season.

The study was continued for two more years. In 2007 and 2008 there were no second broods found, and from 2003-2008 only one-third nest was attempted. During the study, a majority of nest failure for both sites was caused by predation, whereas nest parasitism was low and did not significantly decrease the rate of successful fledging. Though other studies show a potential correlation with elevated predation near natural openings, Rogers' study only shows a slight relationship with predation near gaps (Coppedge et al., 2001; Hallworth, Benham, Lambert, & Reitsma, 2008; Rogers, 2011). Each year of the study, the breeding grounds were found to be population sinks; unable to produce enough offspring to keep the population stable.

Wintering Ground Hypothesis

Climate has an effect on the wintering as well as the breeding grounds. In their study, Rockwell and team assessed multiple consequences the rough climate had on the wintering grounds of the Kirkland Warbler. Late spring and winter rainfall are correlated with low insect populations. Lower prey population appears to be a problem for both males and females, forcing the birds to postpone migration until later in the season until they build sufficient muscle and fat reserves to survive the migration (Rockwell, Bocetti, & Marra, 2012). Not only would males arrive later to the breeding grounds to secure lower quality territories, both males and females would arrive with poorer body conditions *(if able to arrive at all)*, which could

compromise female fecundity. Rockwell's research supported the theory that males would arrive at the site earlier and produce more young where winter rainfall was adequate; however, the birds' difference in size was so little it became insignificant. Breeding site quality was also a factor considered with the reproductive success of the breeding pairs. First year males often arrived later than returning males. It was first believed that first year males had poorer body condition due to dominant adult males monopolizing choice food territories on wintering grounds. After learning that home ranges are more flexible and overlap in the winter, the reasoning shifted to the first year males' lack of experience in muscle building and fat accumulation before the spring migration (Rockwell et al., 2012). Female Kirkland Warblers had different home ranges than males and were believed to be excluded from the more resource-rich wintering grounds by dominant males, though body condition for the females could not be verified. At the breeding grounds, reproductive success as well as clutch size was often lower the later the pair bred in the season.

In another study, Johnson and a team studied six different wintering grounds and their effects on American Redstarts (*Setophaga ruticilla*), neotropical migratory songbirds. The sites studied were citrus orchards, shade coffee plantations, mangrove, coastal scrub, coastal palm, and dry limestone forests. Redstarts wintered the most in the natural mangrove, but were also seen in the citrus orchards and coffee plantations. Few birds were found in the dry limestone forest. Body mass did not differ greatly for adult birds; however, yearlings were found to be lighter in the rougher, less populated dry limestone forest. The rate of survival was highest for all the natural wintering grounds except for the dry limestone forest. Though all the sites *(excluding the dry limestone forest)* held a high overwinter survival rate, the unnatural citrus and coffee sites had low rates of survival in winter *(which included fall and spring migrations as well as the breeding period)* (Johnson, Sherry, Holmes, & Marra, 2006). When focusing on the American Redstart, plantations do not seem to be problematic. However, more specialized species, such as many warblers, are dependent on undisturbed forests. This study would have been more valuable if more specialized songbird species were studied as well.

Methods

Study Site

One study site was visited weekly during our research in Viola, Kansas from mid-April to mid-May. The Wichita State University Field Station at the Ninnescah Reserve contains 133.5-ha restored prairie, wetlands and riparian woodland; our focus was centered on the almost 81-ha riparian woodland along the Ninnescah River. The reserve has fences surrounding the area and ending at the Ninnescah River. The Wichita State University Endowment Association acquired the site in 1983.

Territory Mapping and Nest Monitoring

We located nests by following adult Gnatcatchers with nesting material and by listening for calls. Using a GPS, we marked nest locations for monitoring through June. Once a sample of nests were marked, researchers returned weekly, viewing the nests through binoculars and monitoring adult behavior. Unsuccessful nests were evaluated for cause of failure and the area was searched for any rebuilt nest.

Statistics

To calculate the breeding population, we used the equation for population (λ) = adult annual survival + (juvenile annual survival x the number of female fledglings per female per year). For the population to increase, λ must be greater than 1 (Rogers, 2011). The data collected by Cipra (2013) from two previous years of the study were combined with this season's data to calculate the fledgling survival rate.

Results

Nest Success

Three of the five nests failed during the season. Two of the failed nests were abandoned, intact with unknown contents. One of the failed nests was partially disassembled and in the process of being recycled; the rebuilt nest was not found. One nest had unclear success past the incubation period. The final nest found latest in the season survived past incubation, but successful fledging was not clear.

Population Stability

After combining data from past years of the study, λ for the Blue-gray Gnatcatcher was found to be .209 at the Ninnescah Reserve (Cipra, 2013). In the previous study by Rogers on the Cerulean Warbler, λ of the two study sites was .773. The fledgling survival rate for the Blue-gray Gnatcatcher population not only being lower than one, but being significantly lower than the population growth of the Cerulean Warbler does not support our hypothesis that breeding grounds are the cause of Cerulean Warbler decline.

Discussion

Our results indicate that the population rate for the Blue-gray Gnatcatcher at this study site is declining. The calculated λ from this study in comparison to the previous study of Buehler et al. (2008) on the Cerulean Warbler was significantly lower. This does not support our hypothesis that the breeding ground conditions are the cause of Cerulean Warbler declines. However, due to the extreme drought conditions the site has suffered in recent years, the results may be affected. The low water levels of the Ninnescah River have already had an effect on other wildlife reliant on the river, such as several species of fish (Kansas State University, 2013). The failed nests were found farther from the river than the final two, longer surviving nests. Nests built in late May and early June survived longer than those built in April and early May. Most of the nests were built in May.

The sample size of nests was small due to availability. It is possible that nests were missed during the study because of their distance from the ground, or because they were constructed between visits. Cause of nest failure was not determined for any of the failed nests, though known nest predators were found throughout the site, such as Eastern Fox Squirrels (*Sciurus niger*) and Blue Jays (*Cyanocitta cristata*). One nest survived an attack by a Barred Owl (*Strix varia*). Brown-headed cowbirds (*Molothrus ater*), a common nest parasite, were also seen at the site (Kershner, 2001). More frequent visits to the study site may have discovered more nests and determined the cause of failure. Since none of the nesting pairs of Gnatcatchers were banded, it was unclear if nests were rebuilt nests or late build nests.

To further test the breeding ground hypothesis, a healthy study site with a larger population of breeding pairs of Gnatcatchers should be studied. The drought-damaged site can still yield valuable data; if the Gnatcatcher can maintain a stable reproductive rate on a healthy breeding ground, but not the damaged breeding ground, there would be more evidence supporting breeding ground remediation. Besides offering more evidence supporting the impact of quality breeding grounds, the use of more than one site during the study would increase the chances of finding more reliable data. Another way to test this hypothesis would be to compare the reproductive rates of another stable Neotropical migratory songbird in addition to the Blue-gray Gnatcatcher. This species would have to reflect similar adult survival rates as the Cerulean Warbler and the Blue-gray Gnatcatcher.

Conclusion

Though the data did not support the hypothesis that the deteriorating breeding ground conditions are causing the population decline of the Cerulean Warbler, further research is required. Fewer Gnatcatcher nests were attempted in 2013 at the Ninnescah Reserve than in previous years of the study. If the results of this drought-damaged site were compared to those of an undamaged breeding site, conservation biologists would have more reliable data to analyze the cause of the Warbler's decline.

Acknowledgements

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Computer Aided Design of Drug Delivery Systems

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Abstract

The drug and pharmaceutical industry is a multi-billion dollar business that spends billions of dollars every year trying to optimize drugs and the way they are delivered to the body. Researchers and drug companies alike are mostly concerned with both the quantity and duration of drug presence in the body. Formulating new technologies and delivery mechanisms is a very cumbersome process that can take more time and money than is desirable. In order to arrive to improved and more efficient drug delivery mechanisms, faster and cheaper, the use of computer aided design for drug delivery systems can be utilized for the optimization of drug delivery. This involves simplifying the geometry and physics of certain drug delivery proposals, and solving equations that explain the simplified physics using computer software. The focus of this research was to use computer aided design to model certain drug delivery scenarios, with the goal in mind to optimize these drug delivery systems and their mechanisms. Our computer models can provide insight into the different mechanisms involved, and help find the different variables that can be altered for more desirable drug delivery systems. For this research, fundamental mathematical equations of transfer processes, relying heavily on mass transfer principles, between the drug delivery system and mediums were formulated. Initial conditions for the drug delivery system and their appropriate mass transfer principles were put into COMSOL Multiphysics; the software was primarily used to set up and solve our computer models. Once our computer models were designed and ready, different simulations were run changing specific variables in order to best observe how certain variables can affect a drug delivery system. These models can be used later to optimize current drug delivery systems.

Introduction

For centuries humans have been using and administering therapeutic drugs, and through the years the creation and administration of drugs has grown into a multi-billion dollar business. Hospital and clinic sector expenditures came to a total of 307.5 billion dollars from the years 2009 to 2010, making it one of the largest industries of the United States (Hoffman et al., 2012). With varying new forms of sickness and disease plaguing humans every day, the need for novel, effective, and more efficient drug-delivery mechanisms is always present. Attempts to deliver therapeutic agents to the body has been around for many years, with some of the earliest examples of drug delivery involving chewing certain herbal plants or burning and inhaling other organic substances (Brunner, 2004). These very early attempts to deliver therapeutic healing lacked what many researchers today try to accomplish: a drug delivery system that gives a consistent and effective therapeutic drug dose within the body for a certain amount of time. This is now the foundation for developing novel drug

delivery systems which attempt to give the body a regular, constant, effective dose of drug (Paolino et al., 2006).

The aim of this research was to explore the methods of optimizing drug delivery systems with the use of mathematical modeling and computer-aided design. The approach to enhance the delivery of therapeutic pharmaceutical drugs, for many decades, has been to conduct trial and error experimental studies. This method is quickly being supplemented with the use of mathematical software to predict probable experimental outcomes. A literature review was done to learn the basics of building a computer model to accurately simulate biological processes. From there this research was narrowed down into the modeling of microspheres, considering specifically polymeric encapsulated microspheres. Current mathematical and computer modeling techniques for microspheres were researched and discussed to show how computer modeling is used to understand and enhance drug delivery systems.

The authors then worked to create a mathematical and computer model to simulate different drug diffusion profiles of microspheres of various sizes with varying polymeric molecular shells and thicknesses. First, a mathematical model was established to explain the physical phenomena occurring during the diffusion of the drug through the microsphere. Once the governing equations were established the mathematical model was rationalized, and a computer model was built with the use of COMSOL Multiphysics software. There, a geometric layout of the microsphere was built, along with boundary conditions and material diffusion coefficients that were acquired through a review of the literature. Once the model was complete, time dependent simulations were run through COMSOL, to see how different polymers, shell thicknesses, and microsphere sizes affect diffusion of certain drugs.

The goal of this research was to acquire proficiency in the use of mathematical and computer modeling to optimize drug delivery systems. The ultimate goal of this research is eventually to be able to model drug elution and biodegradation of stent systems within the body. However, getting familiar with the methodology involved in this project was of primary concern. Therefore, the focus was learning the COMSOL Multiphysics software platform, and how to create models of drug delivery systems and explain them mathematically. The model and studies presented here show the versatility of a computer drug delivery model.

Literature Review

There are many forms of drug delivery, but a drug delivery system can simply be defined as a mechanism to introduce therapeutic agents into the body. The techniques and methods that paved the way for modern drug delivery systems started in the early nineteenth century. These early drug delivery methods included pills, syrups, solutions, extracts, emulsions, suspensions, cachets, troches, lozenges, nebulizers, and many more. Many of the drugs delivered by these methods were extracted and derived from plants (Paolino et al., 2006).

The goal of drug delivery is simple, but the design conditions for a drug delivery system requires close attention to drug properties and its consideration to biocompatibility, as well as its ability to target the wanted system. The type of delivery vehicle, the mechanism of release, and the duration of the delivery are also taken into consideration. It is not easy to resolve all of these concerns in a single effective drug delivery system. Even more difficult is producing a drug delivery system that is reproducible and reliable. Even with today's advanced technology and practices this still remains a problem. Now, in the 21st century, the pharmaceutical industry is struggling with the pressures of making affordable and readily available drugs when increasing costs make it more difficult to discover and develop successful drug delivery systems (Paolino et al., 2006).

New chemicals and novel drug delivery systems come with a hefty price tag. The average cost for the development of a new chemical comes to approximately half a billion dollars, and the time it takes to discover is, on average, about 10 to 12 years. Developing a successful, groundbreaking drug delivery system can cost 20 to 40 million dollars, and take up to four years to create. There is a definite need to develop these chemical entities and drug delivery mechanisms, but the resources and time that it takes are sometimes too great (Verma & Garg, 2001). The time and money alone constitute a huge problem, inhibiting the creation of new drug delivery systems and the optimization of current ones. Many

variables can affect delivery systems, and the experimental methods that optimize them can take much man-power and deep pockets. Even when time and money are available, researchers must work to improve efficacy, reduce sides effects, keep a continuous dosing or sustained release profile, increase the ease of use and compliance, and reduce the pain of administration, all major problems that researchers are working on today (Brunner, 2004).

To overcome some of these challenges, new technologies to administer drugs have begun to emerge. For example: sustained release technology, targeted drug delivery, enhanced absorption and transport technology, implantable constant or controlled release technology, pulmonary systemic delivery, and transdermal and intramuscular technology, just to name a few. These require extensive research, including experimental trials *in vitro* and, even more expensive, *in vivo* clinical trials on animals and eventually humans.

Computer Modeling

For this reason, many pharmaceutical researchers have turned to mathematical and computer modeling techniques to solve the problems that plague the optimizations of drugs and their delivery mechanisms. Nowadays, researchers are able to take advantage of advances in computer technology and modeling software and utilize it to better understand and imagine novel drug delivery systems. Computer modeling of drug delivery systems is an emerging field in which interdisciplinary collaborators tackle very complex drug delivery problems. This multidisciplinary approach involves engineers, physicians, and mathematicians (Dua & Pistikopoulos, 2005).

A computer model, like any model, attempts to simulate a particular system. When researchers develop a model on a computer they mean to develop a replica of some physical process that can be simulated and manipulated in a computer. These models can be used for various purposes, but the main attraction is how they allow the researcher to explore different scenarios in the replicated physical process, and understand how the system will react to certain variables or environmental conditions, all without complex and expensive experiments. In short, a computer model involves simplifying the

physics and geometry of a particular situation and solving simplified equations that explain the physics and geometry, using a computer as the main equation solver (Rakesh, 2010).

A computer model can run on a single computer or a network of computers and is limited only by the computational power, software, and storage space one has available. Currently, computer models have been used to gain insight into fields like economics, psychology, astrophysics, and engineering. A simple example would be modeling building structures near fault lines to see which types of materials and designs best withstand earthquakes. In this case, a team of engineers and architects may design several building structures in a computer and run them through a battery of computer simulations before actually erecting a physical building. Before, even one cement brick is laid down they may have gone through hundreds of simulated buildings and situations to determine which combination of structure and material has the highest resistance to certain earthquake forces. Similarly a car manufacturer may run simulated crash tests on concept cars in a computer before any prototype is actually built, saving money and time (Rakesh, 2010).

The same techniques are used when modeling biological transport processes, and they come with the same advantages. Using computer models can save many of the resources one would normally spend to conduct experiments. Costly experiments can go awry; they take extended amounts of time. Computer models, on the other hand, can run multiple experiments with the push of a button and simulate them much faster. As a car manufacturer might model a concept car before constructing a very expensive prototype, so a pharmaceutical researcher could conduct certain drug release profile simulations, or simulate different possible drug capsule geometries reacting in the body, before ever synthesizing a chemical agent. While the procedures of experimental testing *in vitro* and *in vivo* cannot be eliminated, they can be better directed by the clearer understanding given by computer models (Rakesh, 2010).

This stems from a computer model's ability, once built, to modify and change according to its user's needs. By using a model, a researcher can repeatedly test "what if" scenarios on the many different

variables that affect a drug delivery system. The right computer model is as capable as its designers and can calculate whatever variable they deem necessary. A model can simulate different drug release profiles within the body, different polymer matrixes and their degradation, types of chemical drug structures and how they target different organ systems. Once the model is created, one can test numerous situations to try to optimize the drug delivery system at hand. More importantly, researchers can do this without expending large amounts of money, and they could theoretically run an infinite number of simulations. If they were to do a physical experiment, they would only have so much time before they exhausted their budget.

Developing a Mathematical and Computer Model of Biological Transport Processes

Computer models can take into account major biological processes like fluid flow, heat transfer, and mass transfer. Fluid flow denotes the way liquids and gases move through a space. Heat transfer refers to the movement of thermal energy due to conduction, convection, or radiation. In a clinical setting thermal therapy is any treatment or technique that elevates or decreases the cell or tissue temperature for therapy. Mass transfer principles are more important when drug delivery is involved. Mass transfer refers to the movement of a material due to diffusion and convection. Whether it is influencing a tablet taken orally or a drug patch administered transdermally, mass transfer is always in play (Rakesh, 2010).

Creating the Computational Domain

When developing a model, simplification can lead to a less complex problem. There are many reasons that researchers might simplify a model. Some software resources may not be able to handle the required complexity of a certain problem, or the storage space required may exceed the space available. Even when attempting to solve a very complex problem, solving simpler models of the problems first offers insight and knowledge into the broader problem at hand. Therefore, setting the computational domain is important to model formulation. The computational domain is the chosen area of the physical domain where the computations will be performed. The larger a computation domain gets, the more computation is required (Rakesh, 2010). Many

factors, including computation speeds and memory limitations, play a role in choosing a computation domain.

Selection of Regions and Dimensions

There can often be many different regions involved in a problem. A region, which may also be called a subdomain, is just a space or material confined to its own boundaries. For example, a pill made of two different solid and liquid components or a tablet with two or three different solid materials. In a computational domain, not all the regions need to be included. Depending on the physical process in which a researcher is interested, one can restrict the model to only some of the regions present in the problem. For example, if the drug delivery system involves blood flow and the arterial tissue surrounding the blood, it may be possible to keep the model in completely fluid form, while keeping the arterial wall as a boundary condition. A boundary condition is simply the set of conditions specified for the behavior of the solution to a set of differential equations at the boundary of its domain. The problem formulation could be made completely solid while keeping the fluid as a boundary condition in the computation domain. Depending on the physical process, the researcher may have to consider both regions in the computation domain, complicating the problem at hand (Rakesh, 2010).

Connections between the regions also need to be considered, because at the interface of multiple regions, for example in a metallic stent with a polymer drug-induced coating, the line drawn at the interface, is shared by the two regions on either side of the interface. This means that the line at the interface maintains continuity between the two regions, so that changes of energy or mass on either side of the interface are the same. As previously stated, the larger the computation domain the greater the requirement for computational memory and time. Computation time will often disproportionately increase with the number of nodes, discrete locations in the computation domain where computations are performed (Rakesh, 2010). Therefore, the choice of an appropriate domain is important, and can stem from an analytical solution, experimental data, or intuition.

Even though all actual biological transport processes occur in three dimensions, choosing a two or even one-dimensional domain decreases complexity in the model and the time it takes to run. To decide on the necessary dimensions for the computation domain, the dimensions along which the greatest number of changes occur in the variables of interest is usually chosen. Specifically, the geometry chosen for the domain can be one, two, or three-dimensional. For example, in a study of the diffusion of oxygen through a contact lens, concentration variation can be considered primarily one-dimensional perpendicular to the lens surface. The curvature of the lens and cornea can be ignored and considered planar since the thickness of the lens and cornea are small compared to the radius of the sphere (Rakesh, 2010).

Governing Equations

To describe the model, many different mathematical equations may be used, each describing distinct physics and processes related to the drug delivery problem. The physical processes mentioned above *(fluid flow, heat transfer, and mass transfer)* will be the subjects of the following section. The equations chosen change from problem to problem and are applied either to the entire computational domain that has been chosen, or only to individual subdomains. Subdomains are specific regions within the entire computational domain. They may require different diffusion equations or mass transfer principles; therefore carefully selecting appropriate equations is vital in formulating an accurate computer model. The governing equations contain the universal laws that are present in the overall system, like conservation for total mass, momentum conservation, energy conservation, and mass species conservation (Rakesh, 2010). The governing equations, within them, explain the universal laws with different terms. As the Pythagorean Theorem accounts for the three sides of a triangle with variables a, b, and c, so governing equations also have sections within them that account for different variables, or terms. The terms selected by the researcher depends on the particular physics the research is investigating. The governing equations mathematically explain terms like convection, diffusion, transience, and generation. For example convection applies to both heat and mass transfer equations, and represents the transport of energy or species due to bulk flow. This term is kept when the computational domain is a fluid, and where the movement of fluid is expected. Diffusion represents energy transport and its contribution from conduction or diffusion. Diffusion remains in the governing equations when the domain suggests that diffusion is likely to be playing a role in the system. In terms of heat transfer, generation represents the contribution from volumetric generation of heat, converted from some form of energy. When heat or metabolic generation is present in the computational domain, generation is kept in the governing equations. Transience represents change of storage dependent on time, and calculating this change can consume a great deal of computer time and can also be very challenging mathematically. When a change over a period of time is expected to happen, it is important to decide whether the transient term should be retained in the governing equations. If a steady state can be obtained for most of the period of interest, the transient term from the governing questions can be dropped. Otherwise the transient term needs to be left in the governing equations (Rakesh, 2010).

Boundary and Initial Conditions

A computer model must have a boundary condition and an initial condition from which it will start to formulate data. The boundary conditions are the statements describing how the process at hand relates to its surrounding environment. Without any distinct boundaries, the description of the mathematical or physical process will not be complete. Concerning boundary conditions, two questions need to be answered: how many boundary conditions are needed, and what the boundary conditions are. How many boundary conditions there are is determined by the governing equations chosen to encompass and explain the drug delivery system. What those specific boundary conditions are depends on other factors. A quick example: if a researcher were solving for the variable concentration, using the diffusion equation for a three-dimensional cube, six boundary conditions would be needed for the six surfaces. If a researcher were only using a two-dimensional square, they would only need four boundary conditions for the four sides of the square. At each individual surface there is usually only one boundary condition that can be specified, or an oversimplification of a boundary will occur which can cause problems within the model and eventually lead to results that are

incorrect. When working with biological transport processes, boundary conditions can change with respect to time. For example, the temperature at a surface may fall as it is exposed to a cold environment (Rakesh, 2010).

Mathematical and Computer Modeling of Microspheres

Polymeric systems have been used in pharmaceuticals for many years to provide controlled release of therapeutic drug. Many drug and polymer systems can be useful for the protection of drugs from the biological degradation within the body prior to its release. The development of these polymeric/drug devices starts with the use of non-biodegradable polymers. These polymeric systems rely on diffusion processes to deliver therapeutic drug to a specific area. Progress can then be made into using biodegradable polymers that erode or swell. The drug release mechanism that takes place in a polymer is based on the physical and chemical properties of that polymer. Depending on the characteristics of these polymer matrices, the drug release mechanisms can be categorized into three main types: diffusion, swelling, or erosion-controlled systems. In all three systems, diffusion is a factor in the process. For a specific diffusion-controlled process, the drug diffuses from a non-degradable polymer encapsulation. The idea of a swelling-controlled system is to be able to provide more control over the release of the therapeutic drug, particularly when the diffusivity of the drug in the polymer is very low. In this case, water can be absorbed into the polymer matrix, which causes polymer disentanglement. This polymer results in swelling of the polymer, which enhances diffusion and increases the drug mobility. Erosion-controlled systems make drug delivery more versatile because their chemistry and surfaces can be tailored to stabilize macromolecular agents and enhance specific tissue targeting. As erosion-controlled systems like the loss of polymeric material begin, due to degradation of the polymeric chains, drug is released from the polymer matrix (Siepmann, Siegel, and Rathbone, 2012).

Many different approaches are used when modeling polymeric drug release from microspheres. In a study using Monte Carlo simulations (Gao, 2011), researchers attempted to create a mathematical model that would describe all phases of drug release from bioerodible microparticles. They then evaluated the validity of the theory with experimental data and used the model to explain the release mechanisms in *polylactic-co-glycolic acid* (PLGA)-based microspheres. Polymeric degradation is a random process, and it is not possible to predict the exact time point at which particular ester bonds located at specific points begin to cleave with water inhibition. Monte Carlo techniques were used in this case to simulate random degradation behavior of a large population of cleavable polymer bands with acceptable accuracy. Monte Carlo techniques contain a wide range of computational algorithms, which relies on repeated random sampling to obtain numerical results. This is done through running simulations many times over in order to calculate those same probabilities heuristically, similar to someone playing a card game in a real situation and recording their results every time. To save computation storage and time it was assumed that the microparticle was rotational symmetric, thus allowing them to obtain a two-dimensional cross-section with two-dimensional pixel grid that was used for numerical analysis. The "lifetime" ($t_{lifetime}$) of a pixel was calculated as a function of the random variable ε (integer between 0 - 99). The final equation being:

$$t_{lifetime} = t_{average} + \frac{(-1)^{\varepsilon}}{\lambda} \times \ln\left(1 - \frac{\varepsilon}{100}\right)$$

where $t_{average}$ is the average "lifetime" of pixels and λ is a constant, characteristic of the type and physical state of the polymer. The idea here is to treat erosion of a polymer pixel as a random event, which can be described by a Poisson process of first order. The diffusional mass transport processes were described using Fick's second law of diffusion for cylindrical devices shown below.

$$\frac{\partial c}{\partial t} = \frac{1}{r}\left\{\frac{\partial}{\partial r}\left(rD\frac{\partial c}{\partial r}\right) + \frac{\partial}{\partial \theta}\left(\frac{D}{r}\frac{\partial c}{\partial \theta}\right) + \frac{\partial}{\partial z}\left(rD\frac{\partial c}{\partial z}\right)\right\}$$

Here, c is the concentration coefficient and D is the diffusion coefficient of the drug, r denotes the radial coordinate, z the axial coordinate, θ the angle perpendicular to both axes and t represents time. Mathematical analysis was reduced to one quarter of a sphere because two symmetrical planes exist in the spherical microparticles. The entire mathematical model derivations and boundary conditions were

explained in full by Gao (2011).

One major advantage of their proposed mathematical model is how it takes the heterogeneity of the inner structure of the microparticles into account. When the microparticle is exposed to the release medium, water is rapidly absorbed into the system and dissolves the drug, which then diffuses out. Their model was able to quantify drug release from bioerodible microspheres while considering dissolution, diffusion with non-constant diffusivities and moving boundary conditions, polymer degradation/erosion, time-dependent system porosities and the three-dimensional geometry of the device. Many previous models could not accurately describe all three observable phases of drug release: the initial burst, subsequent approximately zero-order drug release, and second burst phases. This model allows researchers and pharmaceutical companies alike to gain insight into the underlying chemical and physical mechanisms involved in the control of drug release. For example, a drug manufacturer could use this model to predict the effect of different formulation and processing parameters on the resulting drug release kinetics of bioerodible microspheres (Gao, 2011).

In a separate study, two different groups of models were used to explore the possible effects of drug release patterns on different erosion mechanisms. These models have been developed by incorporating an erosion term into the dissolution and diffusion equations, and were used by Arifin, Lee, and Wang (2006) for modeling bulk and surface erosions. In this study of simulating drug release from biodegradable polymeric microspheres, the bulk erosion model made many assumptions. It assumed that the drug carrier would be in spherical form with an initial radius R_0, and made of a non-swellable polymer. The bulk erosion process was assumed to happen homogenously inside the microsphere, and the effective diffusivity depended only on the changes of porosity and tortuosity in the microsphere. Finally the porosity and tortuosity changes were assumed to be proportional to the volume change of effective solid phase. Three phases were considered in their model. The first was a liquid phase where diffusion occurred, and which the drug entered through dissolution and erosion. The second was a virtual solid phase, where the erosion and dissolution decreased the amount of drug concentration in the microsphere. The amount

of drug lost in this phase is equal to the accumulation in the liquid phase. Finally, the effective solid phase was used to simulate the actual changes in the solid phase. Here is a brief explanation of their linear erosion model: their "s" erosion model and hyperbolic erosion model are given in Arifin, Lee, and Wang (2006). To explain linear erosion, it was thought that the ratio of amorphous polymer to crystalline polymer and free chains to rigid chains were comparable. Another important factor that was accounted for was the additive. Some polymers are acid catalyzed, and by adding acidic additives, the release of drugs from the polymer is accelerated. The morphology of the microsphere was another factor taken into account. For example, during the preparation of the microsphere, a spray drying method will make the microsphere more porous as compared to those microspheres prepared by emulsion. The greater porosity makes release from spray-dried microspheres faster than those prepared by the emulsion method. Taking these factors into account for the linear model, the following equations were proposed for liquid, virtual solid, and effective solid phase respectively:

$$\frac{\partial C_L}{\partial t}$$

$$= \frac{1}{r^2}\frac{\partial}{\partial r} * \left(D * r^2 * \frac{\partial C_L}{\partial r} \right) + \frac{C_{Se} * K_{Lero}}{B: Erosion}$$

$$- \frac{\frac{\partial C_{Se}}{\partial t} * (1 - K_{Lero} * t)}{C: Dissolution}$$

$$\frac{\partial C_S}{\partial t} = \frac{\partial C_{Se}}{\partial t} * (1 - K_{Lero} * t) - C_{Se} * K_{Lero}$$

$$\frac{\partial C_{Se}}{\partial t} = -k_{dis}(\epsilon C_{sat} - C_L)$$

Where C_L, C_S, C_{Se} is drug concentration in liquid, virtual solid, and effective solid phases respectively, and the dissolution term is $k_{dis}(\epsilon C_{sat} - C_L)$, because the rate of dissolution is proportional to its driving force, which is the difference between the actual and saturation concentrations. The linear erosion, hyperbolic erosion, and "S" erosion equations were solved together, under certain boundary conditions, to investigate the drug release pattern under different erosion mechanisms.

When a microsphere undergoes surface erosion, the size of the sphere gradually decreases, while the average polymer molecular weight does not change significantly. In an ideal surface erosion process, the external medium should not be able to enter into the interior of the microsphere. To be able to determine the amount of drug eluted from the sphere, dissolution of the drug from solid phase, diffusion of the dissolved drug from the solid phase, diffusion of dissolved drug and erosion of the polymer matrix all had to be taken into account. The drug release percentage, which includes the amount of drug from both liquid and solid phases that has exited the instantaneous external boundary of the microsphere, was computed through derivation and set boundary conditions. It is shown below:

$$\frac{M_t}{M_\infty} = 1 - 3(1 - w)^3 \int_0^1 (u_L + u_s)s^2 \, ds$$

The final differential equations for both bulk and surface erosion processes were solved by MATLAB PDE toolbox. When the differential equations were solved the results were compared to experimental data. For the bulk erosion of both hydrophobic and hydrophilic polymers the models were able to show a reasonable match with the experimental results reported in literature. The results also indicated that the surrounding environment has a profound effect on the drug release pattern under a finite mass transfer condition. For various surface-eroding polymers, it was observed that the radius of the microsphere follows an approximate linear profile of reduction with respect to time. With better experimental analysis on diffusivity coefficients, the dissolution constant, and erosion constants, these models could be used to accurately predict outcomes, giving pharmaceutical researchers and manufacturers a head start on developing novel polymeric microsphere drug delivery systems.

These examples provide examples of how modeling works and how it is applied to real world drug delivery systems. Why model microspheres, and more specifically, why model polymeric microspheres? Polymeric microspheres are controlled release drug delivery systems that can be used as an alternative to current conventional drug therapy regimens (Siepmann, Siegel, & Rathbone, 2012). PLGA, for example, is one of the most successful polymers used

in the production of particulates that are used for controlled release mechanisms. PLGA is advantageous because its biodegradable and biocompatible products of dissolution do not require further management once they are introduced into the body (Arifin, Lee, & Wang, 2006). PLGA and other polymers are also non-toxic to the body and can be many times more effective in cell viability than the free drug itself. They have proven their capabilities of easy encapsulation and release of active proteins in a controlled, sustained manner. The ability of these microspheres to release drug molecules in a controlled process over long periods of time, from just a single administration, gives them the potential to be able to maintain drug concentration within target ranges. They also lower the risk of the overconcentration of drug in the body, which can lead to harmful side effects (Siepmann, Siegel, & Rathbone, 2012).

Methods

For the purposes of this study, and to show how a similar model will be utilized for future research, the diffusion of a drug through polymeric shells of microspheres was investigated. The COMSOL Multiphysics interface that was used assumed that all chemical species were transported by diffusion. It was also assumed that all species present were dilute, meaning that their concentration was small when compared to the solvent. Fick's law for diffusion was the primary law used to generate the model's governing equations. Due to time constraints, many assumptions were made, with constants and material properties (i.e. diffusion coefficients) gathered from literature and input into the model. It must be noted that some of these diffusion coefficients of certain polymers or drugs may not relate with respect to one another. While these materials also might not apply to the long-term focus of this research, the methods of analysis and acquiring data are highly applicable to future research. When this research is further developed, diffusion coefficients, material properties and constants will be gathered and validated experimentally for specific polymers and drugs to ensure that all the right values are being applied to the system in order to validate our models. Therefore, for purposes of displaying the mathematical and computer model that was created, different materials and properties were used, to display the versatility of

the model and the COMSOL Multiphysics software platform.

Model Development

Design Objectives
The design objectives for this small-scale study are:

- Design a computer model to evaluate diffusion of a drug from microspheres.
- Demonstrate that the model can simulate different scenarios of varying polymers, polymeric shell thicknesses, microsphere sizes, and initial drug concentrations.
- Analyze drug concentrations inside the initial loading zone with respect to microsphere size, polymeric shell thickness, initial drug concentrations, and varying polymer shells.

Schematics

To simplify the drug diffusion from the polymeric microspheres, the following assumptions were made:

1. The microsphere is spherically uniform and will be modeled as a sphere.
2. Properties are uniform throughout the system.
3. The drug diffuses throughout the entire surface of the microsphere.
4. Drug diffusion happens uniformly, which results in a two-dimensional axi-symmetric problem.
5. The polymer shell is non-degrading and stays constant, keeping the same initial thickness throughout the entire time of simulation.

Geometric Layout

The microspheres were assumed to be spherically uniform and modeled as spheres, but in order to simplify the model the geometric layout was constructed in a two-dimension axi-symmetrical way. This reduced computing time and the data storage requirements of the simulations.

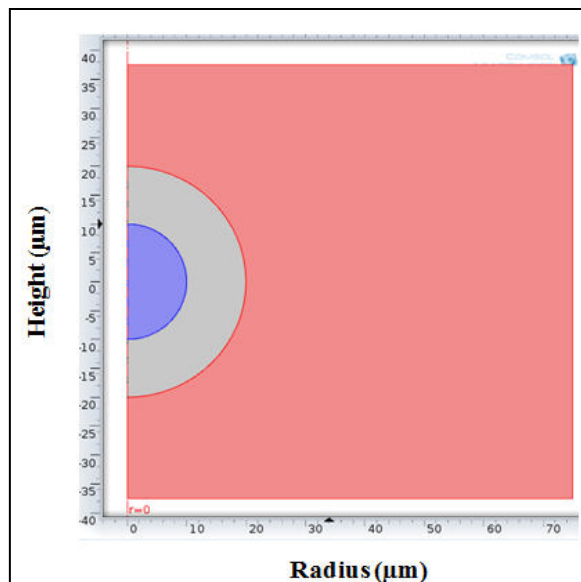**Geometry of Microsphere Created in COMSOL**

Figure 1. Schematic layout of a microsphere 40μm in diameter with a 10μu thick shell. Blue represents the drug.
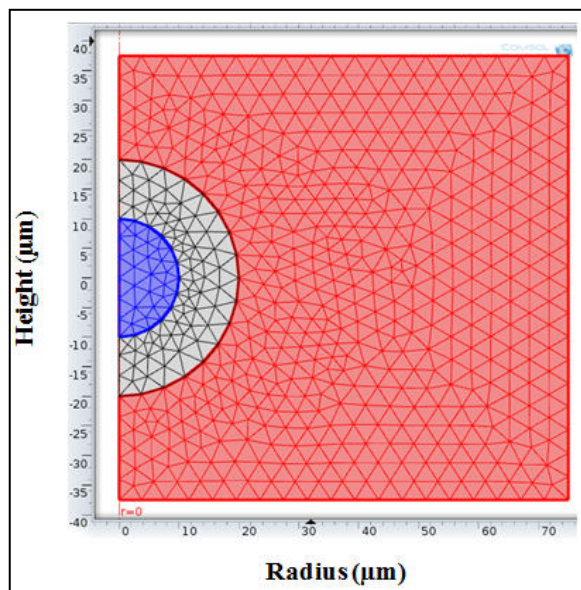

Figure 2. Geometric mesh made up of several triangle elements. 1,131 different elements were generated and analyzed.

To create the geometric layout of the microsphere a two-dimensional construct of half a microsphere was created in COMSOL (Figure 1). COMSOL then rotates the two-dimensional schematic around the r = 0 axis when developing a three-dimensional construct. Microspheres of 5-, 10-, 20-, 30-, 40-, and 50μm in diameter were created. Along with those diameters, varying shell thicknesses were modeled. Shell thicknesses varied from 2μm to 12μm in 2μm increments. Figure 1 shows a simple schematic of the

two-dimensional construct of the microspheres. The blue half circle represents the initial drug-loading zone, essentially the inner space where the drug is encapsulated by the polymeric shell. The grey represents the polymeric shell, and the red represents the solution in which the microsphere is immersed, and into which the drug will diffuse out towards.

To help evaluate the system as a whole, a mesh of triangles was created (Figure 2). The mesh determines the resolution of the finite element used to discretize the model (Vineet, 2010). The mesh used for the finite element method produces a discretization of the geometric domain into small, simple shapes. These small-discretized regions are known as elements, and the sets of points that define these elements are known as nodes. The finished mesh consisted of 1,131 elements. A structured mesh helps to reduce the problem size and uses a set of polynomial functions to approximate the variables that are being measured in the simulation. A finer mesh could have been created, but it would have come at the cost of increased computation time and memory usage. Because of time constraints, the mesh in Figure 2 was deemed adequate to conduct the simulations required for this research (Vineet, 2010).

Mathematical Model

For solving the diffusion of the drug out of the microsphere system, Fick's second law of diffusion was used. Fick's second law helps predict how diffusion causes concentrations of species to change with respect to time (Arifin, Lee, & Wang, 2006; Siepmann, Siegel, & Rathbone, 2012). Fick's law governs the diffusion of solutes, dilute mixtures or solutions. The final governing equation that was derived and implemented was the mass balance equation seen below.

$$\frac{\partial c}{\partial t} + u \times \nabla c = \nabla \times (D \nabla c) + R$$

- c is the concentration of the species (mol*m^{-3})
- D denotes the diffusion coefficient (m^2*s^{-1})
- R is a reaction rate expression for the drug (mol*m^{-3}s^{-1})
- u is the velocity vector (m*s^{-1})

The first term on the left part of the equation, $\frac{\partial c}{\partial t}$, corresponds to the accumulation of the species with respect to time, while the second term accounts for the convective transport due to velocity field u. The right hand side of the mass balance equation, $\nabla \times (D \nabla c)$, describes the diffusion transport, which accounts for the interaction between the dilute species and the solvent. The second term on the right hand side of the equation, R, represents a source term or sink term, typically due to a chemical reaction. Drug was assumed to only move through diffusion, therefore the convection term was eliminated. The equation then becomes:

$$\frac{\partial c}{\partial t} = \nabla \times (D \nabla c) + R$$

Boundary Conditions

For the boundary conditions of the model, it was assumed that the drug diffused in a uniform manner throughout the entire surface of the microsphere. On the right boundary (r = 0), which can be seen in Figure 1, the species flux was zero because the r at 0 was the axis of rotation used to create the three-dimensional construct. The initial drug concentration in the polymeric shell as well as in the medium that the drug would diffuse into, water, was set as $0 \frac{mol}{m^3}$. The surrounding boundaries at the bottom top and left (represented by the red square in Figure 1) were considered opened.

Materials

For the purposes of demonstrating how the model could be utilized, water was chosen as the surrounding medium. For modeling the polymeric shells, Polymethyl methacrylate (PMMA) was used. Insulin was chosen as the drug that would undergo diffusion through the polymeric shell.

Results and Discussion

To run the simulations, values from literature were obtained with regards to diffusivity of water, PMMA, and insulin. The simulations were run for a total of 86,400 seconds (24 hours). Calculations of concentrations at a time step of every 10 seconds of the simulation were done to save computational time and data storage. The first simulations that were conducted used the 40µm microsphere with varying PMMA shell thicknesses. The concentration of drug

in the initial drug-loading zone is displayed in red in Figure 3. The diffusion coefficient for insulin used was 8.3e-7m^2/s while for PMMA 9.55e-15m^2/s was used and 2.3e-9m^2/s for water. Initial drug concentration within the microsphere was 250 $\frac{mol}{m^3}$. Figure 3 is a snapshot of a simulation at time = 0 seconds that was conducted for the 40μm PMMA microsphere with a shell thickness of 12μm and an initial concentration of 250 $\frac{mol}{m^3}$ of insulin. Figure 3A shows a two-dimensional graphic plot of the concentration of insulin at time = 0 seconds of the simulation. Almost no drug diffusion is visible, with almost all of the initial 250 $\frac{mol}{m^3}$ of the insulin concentration still encapsulated within the PMMA shell. Figure 3B is a three-dimensional plot of this process.

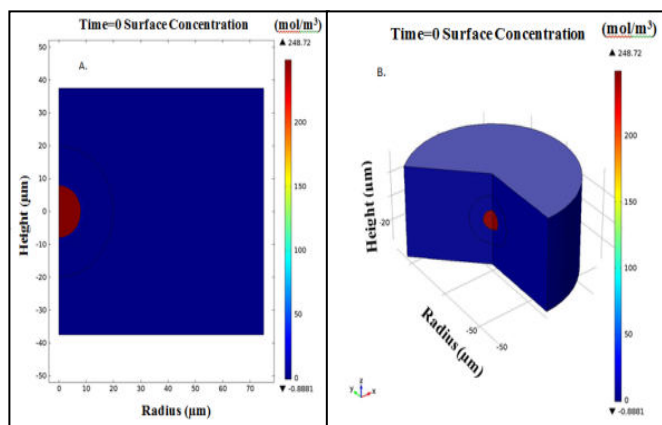*Figure 3. Plot of the surface concentration throughout the system at time = 0 seconds for a 40μm diameter microsphere with a 12μm PMMA shell thickness. Part A shows the two-dimensional concentration plot while Part B shows the three-dimensional concentration plot.*

As the simulation proceeded, drug was expected to diffuse through the polymeric PMMA shell and into the water. Figure 4 shows that at 6,000 seconds there is a clear indication of this occurring. The concentration meter seen at the right of the graphs in Figures 4A and 4B indicate that the concentration range rose from about 0 to about 65 $\frac{mol}{m^3}$. 74% of the insulin has already diffused out of the PMMA microsphere initial drug-loading zone within the first 6000 seconds of the simulation. Figure 4B shows the three-dimensional representation of the concentra-tion seen in Figure 4.
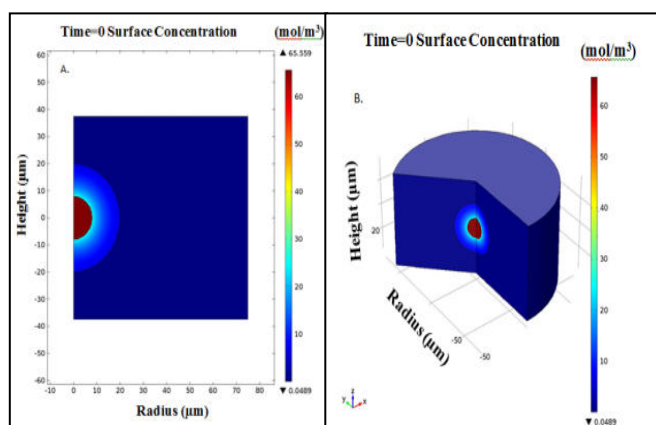

Figure 4. Plot of the surface concentration throughout the system at time = 6,000 seconds for a 40μm diameter microsphere with a 2μm PMMA shell thickness. Part A shows the two-dimensional concentration plot while Part B shows the three-dimensional concentration plot.

All simulations in this research were conducted in the same manner, with only the initial conditions of each simulation varying. Six total simulations were conducted, like the one just discussed, to determine how different PMMA polymer shell thicknesses affected the concentration of insulin in the initial drug-loading zone as time progressed. For this particular study all the microspheres were of a diameter of 40μm with an initial drug concentration of 250 $\frac{mol}{m^3}$ in the drug loading zone. The only variable that was changed was the PMMA shell thicknesses. PMMA shell thicknesses of 2-, 4-, 6-, 8-, 10-, and 12-μm were used. The drug concentrations in the initial drug-loading zone of the different simulations from time 0 to 30,000 seconds can be observed in Figure 5. The shell thickness that had 50% of the insulin concentration diffuse out of the initial drug-loading zone was the 2μm thickness with 50% of the insulin diffusing out at around 2,280 seconds. The slowest shell thicknesses to diffuse 50% of the initial concentration of insulin were the 6μm and 8μm, with 50% of their initial insulin diffusing out by 3,340 seconds. The shell thickness that was the fastest to release 95% of the total initial insulin concentration was the 2μm PMMA thick shell, releasing 95% of its initial insulin in just 11,860 seconds. The rest of the shell thicknesses (4-, 6-, 10-, and 12-μm) released 95% of their initial drug concentration by 18,790-, 22,950-, 23,860-, 21,940-, and 17,620-seconds respectively.
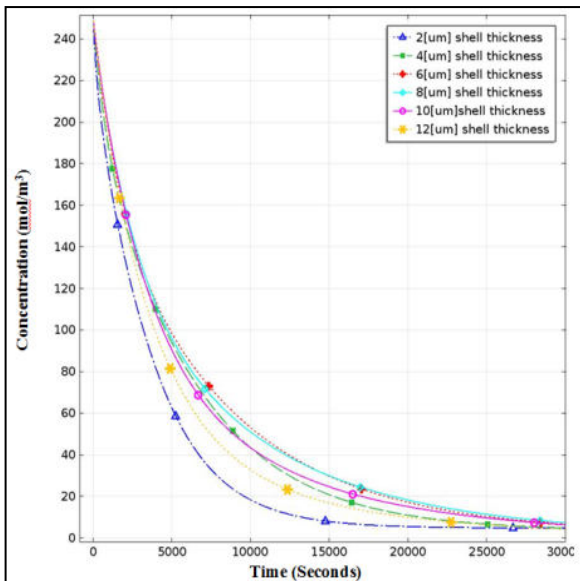
Figure 5. Plot of the concentration in the initial drug-loading zone throughout the first 30,000 seconds of the time study. All microsphere in this graph were 40μm in diameter and had an initial insulin concentration of 250 $\frac{mol}{m^3}$

For the next study, the initial drug concentration was the variable tested while the microsphere diameter and shell thickness were kept constant. This was done to see how a change in initial drug concentration would affect the drug diffusion in the initial drug-loading zone with respect to time. Six simulations were again conducted, starting with an initial drug concentration of 250 $\frac{mol}{m^3}$. In the proceeding simulations the drug concentrations were decreased in increments of 50 $\frac{mol}{m^3}$, with the exception of the sixth simulation, which was only decreased by 45 $\frac{mol}{m^3}$, from the previous simulation to give an initial drug concentration of 5 $\frac{mol}{m^3}$. All the simulations were conducted using a microsphere 40μm in diameter with a PMMA shell thickness of 2μm. Figure 6 shows the results of the drug concentrations in the initial drug-loading zone of the microspheres with respect to time as the initial insulin concentrations changed.

Figure 6 shows that as the concentrations are decreased the rate of diffusion seems to stay the same, and analysis of the data supported that interpretation. All six simulations with varying initial insulin concentrations released 50% of the initial insulin out of the drug-loading zone around 2,280- and 2,290-seconds, and subsequently released 95% of their initial insulin concentration at around 11,860 seconds.

Microsphere size can also play a part in drug diffusion, so we also examined how the change in microsphere size would affect the diffusion of insulin.
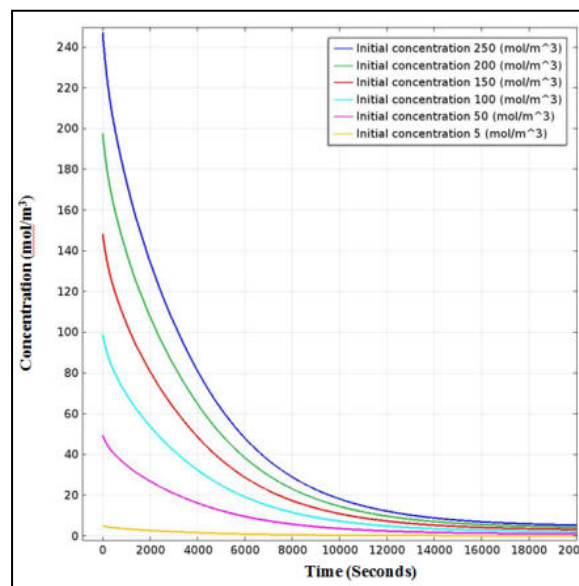

Figure 6. Plot of the concentration in the initial drug-loading zone throughout the first 20,000 seconds of the time study. All simulations in this graph were of a microsphere 40μm in diameter with a PMMA shell thickness of 2μm.

For this study, varying PMMA microspheres were used with the same initial insulin concentrations of 250 $\frac{mol}{m^3}$ and PMMA shell thickness of 2μm. Microspheres of 5-, 10-, 20-, 30-, 40-, and 50-μm were tested.

Figure 7 shows that as the PMMA microspheres are increased in size their rate of diffusion of insulin from the initial drug-loading zone is much slower in comparison to smaller sized microspheres. The 5μm diameter microsphere released 50% of its initial insulin concentration in the first 10 seconds, while releasing 95% of its initial insulin concentration in about 110 seconds. With the rest of the PMMA microspheres (10-, 20-, 30-, 40-, and 50-μm), the diffusion rates generally decreased, releasing 50% of their initial insulin concentrations in 190-, 5,960-, 1,190-, 2,280-, and 3,060-seconds respectively, and releasing 95% of their initial insulin drug concentrations in 1,430-, 1,130-, 7,720-, 11,860-, and 19,060-seconds.
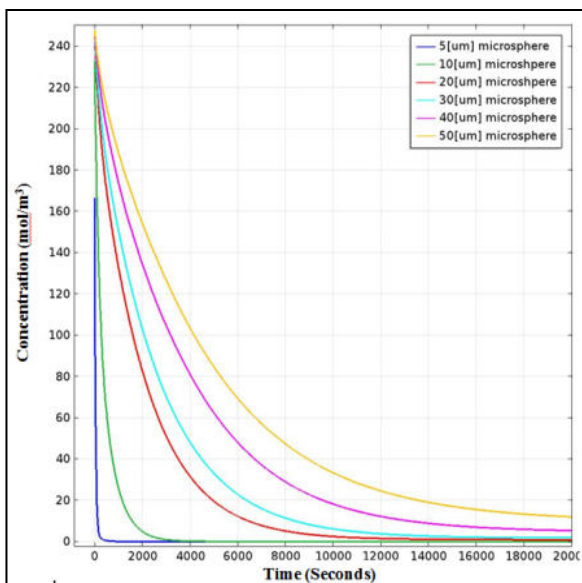
Figure 7. Plot of the concentration in the initial drug-loading zone throughout the first 20,000 seconds of the time study with varying initial insulin concentrations. All microspheres in this graph were 40μm in diameter with PMMA shell thicknesses of 2μm.

Conclusions

A computer model was created to model the diffusion of a drug though a polymer encapsulation and into a medium. This versatile model was able to show that it could investigate the different variables of a certain drug delivery system (in this case non-degradable polymeric microspheres) and give insightful data that could then be further analyzed to examine how the drug delivery system reacts with certain variable changes. Governing equations were selected, with initial and boundary conditions specified. Different polymers, shell thicknesses, microsphere sizes, and drug concentrations were successfully evaluated. Simulations were conducted to determine how these different variables affected the overall system and diffusion of insulin. This model proved that it could simulate multiple scenarios and environments and return data that was relevant to the drug delivery system as a whole. The goal of this research was to gather, understand, and implement the methods of computer-aided design of drug delivery systems. Overall the design objectives were completed, and the researchers hope to expand on its success in the future.

Design Recommendations

For future initiatives the model could be expanded upon to evaluate biodegradable polymers and the mechanisms of drug diffusion as a polymer degrades. For example, there was work put toward modeling multiple polymers in different simulations, but due to time constraints those studies went unfinished. Work will resume to finish those studies and further improve the model. There are also different microsphere drug delivery systems, such as swelling and erosion systems, which can be added to increase the versatility of this model. Also, mesh construction should be more carefully considered; a more defined mesh could be created to allow for greater accuracy in drug diffusion profiles. A study of the type of polygonal shape and number of elements could investigate how the mesh of the system affects the concentration values, and determine whether or not there are noticeable variations in data being collected. Experimental data should be gathered to validate material constants like diffusion coefficients. Specific diffusion coefficients for drugs and their diffusion in various polymers and mediums can be experimentally acquired and then applied to their respective models.

This model was limited to a one-species transport of diffusion but could be expanded to model multiple species like drugs, proteins, and polymeric degradations diffusing simultaneously. After it is optimized, an important step in designing any mathematical or computer model is to validate one's modeling work with experimental work to see how well the model's data matches real world experiments. Ideally once this model is optimized, the next step will be to validate the data the model gives for each simulation.

Future Work

With the start of the next school year, this research will be built upon to improve the model according to the design recommendations. Lab work is being done to prepare experiments to obtain diffusion coefficients and other material properties for the materials that are focal points in the long-term design of this research. Alongside this research, the authors have been working in conjunction with a graduate student at WSU who is working on modeling the corrosion of metals. The researchers hope that the work done this summer will provide the necessary

tools to model different drug delivery systems and incorporate them into models of corrosion of metals and stent systems, with the goal of accurately simulating drug elution from biodegradable metallic stents.

Acknowledgments

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The Relationship Between Home Literacy, Language Practices and Phonological Awareness Skills in Young English Language Learners

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Summary of Research

Abstract

Within the United States, the English Language Learners (ELL) population has consistently increased. Many ELL students are living in low income communities and are at a higher risk of economic obstacles that may affect their school achievements (Georges, Brooks-Gunn, & Malone, 2012; Leyva, Alison & Reese, 2012), in turn causing a new issue for the school system. Educators have to learn how to teach ELL students in order to keep them at the same level as their peers. All the while, the ELL student is learning a new language at the same time. This is the challenge: trying to teach a student English while at the same time trying to teach them the core concepts behind English. The present study hypothesized that there is a correlation between home literacy practices and phonological awareness (PA) in ELL students. The first step is to understand characteristics that detect future reading abilities (i.e. emergent literacy) and at what age learning them has the greatest effect. The next is displaying the importance of home literacy practices for the future success of a student. The most significant point about Hispanic home literacy was the reason behind why they implement only some literacy practices in the home. If the parents felt the literacy practice helped their children succeed intellectually and morally then the practice would be utilized.

Emergent Literacy

Emergent literacy is a set of characteristics of pre-readers that may relate to later reading and writing (Whitehurst & Lonigan, 1998). Every child comes to school with some type of emergent literacy skills, but the ELL student may be lacking the fundamental skills that many English-speaking students come to school with. This article discusses three different types of emergent literacy: Oral Language, Print Knowledge, and PA. Oral language is based on spoken language learned over a process of time; through oral language vocabulary increases. In previous studies it has been shown that vocabulary is connected to phonological awareness and is a predictor of children's future reading abilities (Leyva, Sparks, Reese, 2012). Print knowledge encompasses conventions of

print and knowledge in English. Conventions of print include knowing how to read from top to bottom, left to right, and knowing a book progresses from front to back. Also included are knowing the difference between pictures and text on a page and knowing the difference between the cover and the pages in a book. Knowledge of letters entails knowing the letters and the sounds they make, and also the ability to translate print into sound and sound back into print. PA refers to abilities such as rhyming, matching, initial consonants, and counting the number of phonemes in spoken word.

Home Literacy Environment

The first step in learning about the ELL student's initial PA skills is evaluating home literacy practices. The present article explains that preschool home language plays a role in a child's literacy development. Burgess, Hecht, and Lonigan (2002) discussed six conceptualizations of home literacy environments (HLE): 1) Overall HLE, 2) Limiting environment, 3) Literacy interface, 4) Passive HLE, 5) Active HLE, and 6) Shared reading HLE. Each conceptualization was equally important but targeted different ways parents integrate home literacy. The result showed that an overall home literacy environment correlated with oral language, phonological awareness, and word decoding ability. Parents are the very first teachers a child has. Previous studies have shown that "vocabulary skills at the beginning of preschool were correlated with phonological skills at the end of preschool" (Georges, Brooks-Gunn, & Malone, 2012; Leyva, Alison, & Reese, 2012). Children enter preschool with the literacy skills that they have been taught in their home literacy environments. Studies suggest that preschool literacy skills have a lasting effect on future reading abilities. A Lonigan, Burgess, and Anthony study conducted in 2000 indicated that emergent literacy skills at the preschool age are important for future reading. Overall, it is suggested that home literacy is of great significance for reading.

Methodology

The present study hypothesized that the more home literacy practices were engaged in, the better would be the literacy skills of the student. There was one research question that guided this study. That question was "what is the relation between home literacy and language practices and PA skills in young

ELL Students?" The study used secondary data analysis on an existing data set of 164 parents and 164 preschool aged ELL students collected as part of a national study. Teachers recruited students and parents based on Spanish being their native language. Testing was conducted over a two-week time frame. The students completed a standardized measure of PA, administered by a trained bilingual tester. The standardized test was comprised of five parts: rhyme, rhyme production, initial phoneme, sentence segmentation, and syllable segmentation. Testing occurred at the preschool in 20 to 30 minutes sessions, three to four times a week. The parents received a survey about home literacy practices and demographics from the teacher.

Results

In order to address the research question two correlational analyses were completed, investigating a bivariate correlation between phonological awareness and the composite variable of home language and literacy practices. Due to age differences a second analysis was conducted; in turn the results were twofold. It was found that language environment and reading environment responses on the parental survey were significantly correlated. On the other hand, there was no substantial relation between PA and HLE.

Discussion

The results showed that there was not a significant correlation. These results may have differed from previous studies, such as, Burgess, Hecht, & Lonigan, 2002, because the present study sample was low-income Hispanic ELL preschoolers. Another reason for differences in this study may be because of the age range used in this present study. The present study used a young (i.e. preschool aged) sample, while other studies, such as, Duursma, Romero-Contreras, Szuber, Proctor, & Snow (2007) used older children (i.e. $3^{rd} - 5^{th}$ grade). Also, the students may have been nervous or frightened because the tester was unfamiliar. There are a few limitations to this study. First, the participants were not randomly selected; the classroom teacher recruited the participants. Secondly, the students' unfamiliarity with the tester may have impacted their performance. Lastly, the parents' desire to please the researcher may have impacted the survey.

Conclusion

The hypothesis was that there is a correlation between home literacy practices and phonological awareness in an ELL student. The results refuted the hypothesis. It is shown that emergent literacy skills are important for future reading abilities. Also, it is shown that phonological awareness at the beginning of preschool indicates the phonological awareness skills at the end of preschool. Previous studies have demonstrated that home literacy practices do affect the literacy skills of a student. This study differs. There are many reasons as to why this study may differ: demographics, age, etc. Though this study does not show that there is a significant correlation between phonological awareness and home literacy practices, this study has the capability to further inform educators on the effects of home literacy in ELL homes.

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The Ecological Impact of Rap Music

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Summary of Research

Abstract

At-risk youth come from diverse backgrounds and may be vulnerable as they struggle between acceptance and identity development during the transition between childhood and adulthood. As youth seek to form their own identities and find a place for themselves within their world, many turn to music as a foundation of this community and identity formation. This qualitative study seeks to answer the research question: in what ways does rapping affect the creation and development of social connections in young men? Through ecological analysis, the study demonstrates how rap music is used by youth to form relationships, tell stories about their lives, and address issues such as trauma. The participants included five males ages 18 - 22. Eco-maps were created for each participant, resulting in a graphic that identifies important groups and individuals in their lives and the communication patterns between them. This study revealed that participants have small inner circles that they relate to more as family than their biological families; a general mistrust exists for people outside of that core group. Findings present an opportunity to learn about the inner workings of young people who are involved in rap music as an activity with peers and as an outlet for processing issues of daily life. By using the ecosystems theory as the foundation of the study, the researcher also applied prevention and risk-focused theories in examining results.

Keywords: rap music, ecological systems, eco-maps, transition-age, adolescents

Purpose of the Study

Adolescence is a time of significant change, during which our identities are formed and influenced by those around us. Youth who create rap lyrics with each other create social connections that assist in the formation of their identities. This research explores the relationship between the creation of social connections and the allure of rapping for youth. The purpose of this study is to explore and document how rap music affects the creation and development of social connections in young men. Through ecological analysis, the study will show how groups of transition-age youth, over 18, use rap music to form communal and social connections, tell stories about their life, and address issues such as trauma. This study seeks to answer the research question: In what ways does rapping affect the creation and development of social connections in transition-age males?

Methods

The participants included five males (Khazi, Ty, Roger, Chandler, and Zhane) ages 18 - 22, each who wrote and performed their own rap music. Semi-guided interviews were conducted with each participant. Interviews covered 6 areas: (1) how the participant views himself, (2) how the participant describes his peers, (3) how the participant describes his family, (4) the participant's educational and employment histories, (5) the participant's childhood and any past trauma, and (6) the influence of rap music on the participant. Eco-maps were created for each participant, resulting in a graphic that identifies important groups and individuals in their lives and the communication patterns between them.

Participants were purposefully selected as a cohort of convenience. Two of the participants were known to the researcher from the neighborhood where they lived and were selected by the researcher because they met the criteria established within the research question. The researcher utilized snowball sampling to identify additional participants.

Limitations

The sample is not representative of youth as a whole. Limitations included the sample size, the sampling methods, and geography. All participants were from a mid-sized midwestern city. This researcher is also not able to state affirmatively that the sample would be representative of rap performers or youth in general. To extrapolate results beyond this study, researchers will need to conduct broader research, using a larger, more randomized cohort.

Themes

Four themes emerged from the interviews conducted: (1) Friends and Family, (2) Trust, (3) Music, and (4) Trauma. In this summary, the development of the central themes regarding trust and trauma will be discussed.

Trust
When discussing trust and family, the results were very mixed. Khazi said he felt he had to trust his family since they were family. Roger said he could trust his mother but didn't feel that trust would be automatic to all family members: "If you're just a

cousin or something, [it] don't mean I am going to trust you." Zhane said trust has to be earned, and it did not matter who they were, even family. Chandler and Ty both said that family was not to be trusted. They both felt that trust was something to give to friends, and trust was not something that belonged in a family.

When it came to the friend group, each participant identified that they did trust this group. In fact, Chandler made trust a condition for anyone entering the group. "They got my trust if they my close friend," he stated. Roger was the most hesitant to state that he trusted anyone. When asked initially about trust, he said, "I don't trust people." Questioned further, he identified a small group of friends that he said he knew he could trust. "If they real…then I trust my real true friends, just like that two or three niggas who are real and there," he said.

We discussed why each participant felt that the group of people they could trust was so small. They discussed earning trust and depending on others as being difficult parts of their lives. Khazi stated, "You got to go through it together to know they can be trusted." By "it," Khazi indicated that they had to have shared experiences of overcoming difficulty to know that the other had done it before.

Overall, trust was rare, with each having a general mistrust for professionals in their lives. They each had a small, select group of friends that they described differently than other friends, and all agreed that trust was something that had to be earned and was not easily given up. While each had a small group of friends (ranging from one to four) who were given trust, and each had varying levels of trust among family members, they each also expressed that they had to make it on their own and could really only count on themselves for what they needed in life.

Trauma
The theme of trauma emerged from a series of questions about events in participants' childhoods. The theme does not represent that the participants had traumatic events in their lives and were aware of it; rather, the participants had traumatic events but did not characterize the events as traumatizing. First, participants were asked if they had ever experienced anything traumatic in their lives. Khazi and Roger didn't say that they had experienced trauma but

described events that occurred while they were infants. They had no actual memory of the events themselves. Chandler had a story about breaking his leg that was so embarrassing that it was traumatic. Ty said he could not think of anything. Zhane clarified and said, "No, not extra traumatic or anything, like murder."

Because Zhane's response stood out for attempting to define "trauma" with something as graphic as murder, the researcher asked him to identify if anything bad had happened during his childhood. He identified that a few things had happened and described them as "horrible." The researcher asked what had happened. Zhane replied, "A couple molestations, a couple drive-bys, a couple robbings, a whole bunch of verbal assaults, just a lot of shit." Zhane said after those things happened, he "didn't tell nobody, just kept it in." When asked if he still held all of it in, Zhane said, "No, I mean, some it I have gotten out, gotten it off my chest, but there is still some shit I haven't told nobody. I mean you can't just say that shit. Who am I gonna tell?" Zhane was asked if he felt that he never had an opportunity to share his story or he just never wanted to tell anyone. He felt that not wanting to tell anyone was maybe one third of why he had not told anyone. The remaining portion was not having an opportunity. He did not want to sit in therapy and "talk to someone who just gets paid to be there."

The remaining questions in the section asked participants if they had experienced events that may be considered traumatic, without defining it as such. Each of the participants identified things that most people would find traumatizing. All five of the participants described multiple adults in their lives who were arrested at home and multiple encounters with police while at home. Violence was a topic identified by all five participants. Zhane and Ty both witnessed domestic violence in their home growing up. They indicated the abuse was frequent, ongoing, and involved multiple people. Both Ty and Zhane stated that they were sometimes abused when the domestic violence occurred at home, often by their mothers' boyfriends. As with domestic violence, Zhane and Ty both reported frequently seeing the abuse of illegal drugs and/or alcohol in the home. Ty said, "Anyone who came over, it was usually to get some" (indicating drugs).

Participants were asked if they or their siblings had ever been in foster care. Roger and Khazi had not been. Zhane said he had not been in foster care but "maybe should have been." Chandler had never been in foster care, but his sisters were. His mother was in prison from the time he was an infant until he was 11 or 12 years old. He lived with his aunt, but his sisters lived with his grandmother. Ty said he and his siblings had been in foster care but could not remember why. He was in and out of home placement for approximately 3 years, the last of which he lived with his aunt. He indicated that in two years, he had eight or nine different homes and only once lived with his siblings before moving to his aunt's home.

Implications

Anyone who works with youth, especially at-risk youth, can benefit from the knowledge gained in this study. Social work practitioners may incorporate these findings into their practice in order to meet the diverse needs of a population often difficult to reach. By following the results that are discussed above, the implications are tied to these findings in each of the thematic areas.

Trust was highly valued in forming friendships and other relationships of importance. Social work practitioners should note that each of the participants expressed that trust was developed through shared experiences, which included the desire to write and perform rap music. Youth placed a high value on these trust-building exercises and found it difficult to develop healthy trusting relationships with others. Social work practitioners working with youth should give attention to the trust-building phase of their work with the youth. Youth should be given opportunities to express themselves, their past, and their current functioning through a mode of expression that is comfortable to them and assists them in feeling free during those expressions.

In regard to trauma, language is important. Trauma is often not defined as such by those who experience it, especially if the trauma is experienced in early life, throughout childhood, or in a prolonged manner. Those who have experienced trauma often must negotiate the impact that these events have had in their lives. In many neighborhoods, those who live with poverty, low resources, or little protection are

isolated from systems of care. In their daily experience, children are more vulnerable in terms of traumatic occurrences.

Youth who have lived such experiences must be met with practices that are accepting of other realities, even if that reality is vastly different from that of the social work practitioner. This speaks to the diversity of experiences and practice. From the findings, we see that when children experience one or more of these traumas, building a trusting relationship becomes difficult. This further implies that social work practitioners must meet the youth in their own environments and allow them to express themselves in the manner they find most comfortable.

Conclusion

Larger studies should look at these findings in more diverse groups. More research needs to be conducted to understand how rapping can facilitate the creation of such close, personal connections among rap artists. However, the research also appeared to indicate that the young men were using their rap lyrics as a means to express events that happened in their lives and to describe emotions that they otherwise may not be able to express. This would seem to indicate that rap music might offer a social work practitioner an entrance into the inner lives of at-risk youth who identify with the rap culture. Social work practitioners who effectively engage youth in services may be able to reach those with the highest risk.

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Why Do I Text Thee?: Text Messaging Motives and Beliefs in Romantic Relationships

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Summary of Research

Abstract

Text messaging has become a major part of college students' communication and is increasing as a way to keep in touch with family, friends, and significant others. With this idea in mind, not only does text messaging impact everyday communication, but interpersonal relationships as well. Within those relationships, recent studies have reported both positive and negative effects of text messaging. However, little if any research has addressed motives for texting within a romantic relationship.

Thus, this study will examine text messaging within romantic relationships among college students to better understand the positive or negative beliefs and motives. How often do people in a romantic relationship report using texting? Does the increase of texting negatively correlate with face-to-face communication? Is there a relationship between frequency of texting in a romantic relationship and the belief that texting leads to more connectedness in the relationship? To answer these questions, an online survey of 221 college students was conducted. Students were asked to report frequency of texting their romantic partner, frequency of in-person communication, and other measures of beliefs about text messaging. Results provided evidence that texting was used to connect with romantic partners and to facilitate intimacy, love and happiness. Additionally, results indicated that positive motives and beliefs of text messaging within their romantic relationship did not always predict positive outcomes.

Introduction

Little if any known work has focused on personal beliefs of how texting may affect romantic relationships. Broadly looking at the literature surrounding text-based communication, Seltzer and colleagues' (2012) results showed that instant messaging was not as effective as other forms of communication at producing hormones indicative of "stress mediation" and bonding. Davila and colleagues' (2012) results showed that depressive symptoms were not highly correlated with social media use and texting. Focusing more specifically on the topic at hand, romantic couples found that text messaging improved their relationships (Pettigrew, 2012). In summary, it appears that, though text-based communication does not necessarily afford the same benefits as in-person

communication, it is still useful and valued, particularly in romantic relationships. Thus, for the current study, an online survey was conducted examining correlations between the amount of text messaging and the strength of beliefs held about the effectiveness in texting within boyfriend-girlfriend and husband-wife romantic relationships. Through this, the aim was to uncover the motivations for text messaging in a romantic relationship. It was hypothesized that as the use of text messaging on cell phones increases in romantic relationships, the belief that it makes the relationship stronger, gives happiness, love, and solutions also increases. Additionally, it was hypothesized that as texting increases, the belief that texting will lead to less confusion in a relationship decreases. Hypotheses were as follows:

H1: As average use of cell phone for texting in a romantic relationship increases, the belief that text messaging makes the relationship stronger also increases.

H2: As average use of cell phone for texting in a romantic relationship increases, the belief that text messaging a significant other often results in solutions increases.

H3: As average use of cell phones for texting in a romantic relationship increases, the belief that text messaging a significant other results in confusion decreases.

H4: As average use of cell phone for texting in a romantic relationship increases, the belief that text messaging a significant other results in happiness increases.

H5: As average use of cell phone for texting in a romantic relationship increases, belief that text messaging a significant other results in love increases.

Additionally, research questions asked how much time romantic partners spent texting each other, the relationship between the frequency of texting and face-to-face communication, and if participants agree that arguments in the relationship start via texting. Research questions were as follows:

RQ1: How often do people in a romantic relationship report using texting?

RQ2: Is there a relationship between the frequency of texting in a romantic relationship and the frequency of seeing the romantic partner in person? As average use of cell phone for texting increases in a romantic relationship, will in-person communication increase or decrease?

RQ3: Do those in romantic relationships agree that arguments in the relationship often start via text message?

Methodology

In order to address these five hypotheses and three research questions, an online survey (using SurveyGizmo) was conducted of 221 college students currently involved in a romantic relationship at a mid-sized Kansas university. Students were given a two-week time period, between April 15 and April 29, 2013, to participate and complete the online survey. In addition to basic demographic questions, such as sex, race, and class standing, the survey contained 32 questions related to text messaging and romantic relationships.

Results

The findings suggested that most of the hypotheses were supported. However, the results from H4 show that there was no relationship between use of cell phones for texting and happiness ($r(219) = .091$, $p = .09$). Some of the research questions' findings were unexpected. RQ1 showed that most partners in romantic relationships text significant others more than 20 times per day, resulting in 80 of the 221 participants texting their partners in this category. RQ2 showed that as the frequency of text messaging in a romantic relationship increased, the frequency of seeing the romantic partner in person also increased. RQ3 showed that the majority of participants agreed that arguments frequently start through text.

Discussion

This study researched the motives and beliefs that college students within romantic relationships have about using text-based communication. It hypothesized that: as text messaging increases, the beliefs that it makes the romantic relationship stronger, gives solutions, creates happiness and increases love. It also hypothesized that the use of text messaging within romantic relationships

decreases confusion within the relationship. Questions pertaining to the amount of time spent texting within a romantic relationship, the correlation of frequently seeing significant others face-to-face versus text messaging them, and the correlation of text messaging creating arguments within the romantic relationship were also investigated. Overall, the data at least somewhat suggests that using text messaging to communicate in romantic relationships is correlated with beliefs that technology will bring about connectedness. With text messaging as a main means of communication, and with technology always moving forward to different types of remote communications, further research is needed to see its effects on romantic relationships and society as a whole.

Conclusion

The current study reveals more positive beliefs and motives than negative beliefs and motives for texting in a romantic relationship. It was hypothesized that text messaging is used because it helps facilitate romantic relationships. This study sought to answer the question of why people text, finding the motives and beliefs romantic partners have about using text-based communication within their relationships. From the data gathered in this study, it was observed that romantic partners had more positive beliefs and motives than negative beliefs and motives. However, it is important to point out that despite most data pointing to the idea that people text to facilitate a relationship, there was evidence to suggest that sometimes texting is used as a means of arguing in a romantic relationship.

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A Qualitative Study of Peer Labeling

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Summary of Research

Abstract

Labeling theory proposes the idea that labeling a person as deviant leads to engagement in unacceptable behavior. Such labeling by authority figures *(parents, teachers and law enforcement)* has long served as a prominent factor in the behavior of juveniles. This proposed research looks to explore and provide a broader view of an overlooked aspect that can also influence juvenile behavior — peer labeling. In order to investigate the influence of peer labeling on juvenile delinquency, and the development of the juvenile self-identity, researchers conducted a qualitative study of a small group of counselors and staff involved with the local Boys & Girls Club. The purpose of this was to examine if a relationship exists between peer labeling and engagement in delinquent acts, and the impact of peer labeling on self-concept and identity.

Introduction

Juveniles and Labeling

Labeling theory serves as the basis in understanding the evolution of maturity within adolescents. Labeling can often result in the exclusion of a person from social groups, and his adoption of a deviant status based on failure to comply with social norms. Many studies have examined the influence of parental and teacher approval on juvenile delinquency. These studies focus on interactions between juveniles and common authority figures. The influence of peer approval has been included in several studies, but received little attention due to the small statistical significance of past quantitative research. Considering the amount of time adolescents spend with peers in their approximate age groups, it is plausible to suggest that peers would have a strong influence on the development of social rules and self-perception, which would also influence the likelihood of deviance.

Labeling and Self-Conceptions

In relation to juveniles, the theory states, "that perceived negative societal reactions lead to the development of negative self-conceptions and greater delinquent involvement" (Adams, et al., 2003, p. 171). Rules can be formal or informal. Formal labeling involves social control agencies such as courts and police; informal labeling occurs among social and peer groups. Formal labeling is suggested to increase an individual's degree of deviance because there are often legal consequences. Informal labels can be based on appearances, associations, and behaviors. These factors are qualified through social norms that are established based on behavioral rules.

Acceptance and Adoption

Studies have found that the more negative labels juveniles are given, the more likely they are to engage in deviant behavior. The general reactions of social groups are factored into the development and acquisition of deviant status. For most juveniles choosing to participate in delinquent activity, a label must be applied, understood, and eventually accepted. Self-labeling perpetuates the transition to deviance (Hayes, 2012, p. 297). Once the label is accepted, the one labeled begins to display characteristics of the label. As a result, labeled adolescents will quickly become attached to social groups similar to themselves; these groups provide acceptance not offered by most of society (Bernburg, Krohn, & Rivera, 2006, p. 70).

Methodology

This research aimed to explore the following overarching question: How does peer pressure influence juvenile behavior? Along with this question, other secondary questions were raised: What makes peer pressure such an influential factor compared to other social interactions, and why? How does peer labeling influence adolescents' views of themselves and others? How do juveniles determine and establish social norms within peer groups?

To explore the issue of peer labeling and its relation to juvenile delinquency, interviews were conducted. Qualitative methods were deemed the best approach to providing a clearer view of the effects of peer labeling and providing possible answers to the proposed questions. A small set of interview questions was developed based on the main research question. In this study, between four to six interviews were conducted with staff members at the local Boys & Girls Club. Information on issues relating to deviant behavior was gathered based on the staff-members' perceptions of the adolescents they interact with on a regular basis. After each interview, an interview memorandum was completed. The transcriptions and memoranda then became the raw data for analysis; common recurring themes and patterns were identified among interviews.

Results

An important objective of this research is to provide in-depth descriptions of peer labeling and its influence on adolescents' decisions. By providing a

study that focuses solely on peer-to-peer interaction, a more concise view will be given on the influence of peer pressure and its significance to the choices they make. The findings suggested that the relationship between peers and deviant behavior is just as important as the influence of parents and teachers. This influence may be due to the amount of time spent with peers in comparison to time spent with authority figures.

Discussion

Through the interviews conducted, several recurring themes were identified. The main theme identified was acceptance, with several supporting subthemes. The first is the *impact* of peer labeling. Here we see the initial struggle with peer pressure, where the juvenile decides whether they should abide by the rules of their peers or those of society. The second was the *acquisition* of a deviant identity. During acquisition the juvenile labeled may begin to self-label and eventually accept their new identity. In turn, they begin to act out in accordance with this new identity. The next theme identified was *neutralization*, where those who misbehaved would blame their peers and society for their choices and behaviors to engage in certain activities rather than taking responsibility themselves. The last theme identified was *maintenance* of a deviant identity. The juveniles often struggled, again, with the issue of whether to abide by society's rules or those of the group of which they had become a part. While there may still be a desire to abide by society's rules, if the status they have achieved, negative or positive, is more in line with their own ideas, then they may continue to follow their peers' rules, defining these as the new social norms and society's as deviant. In conclusion, it is noted that peer influence is a strong factor in juveniles' decisions.

Conclusion

This research set has looked more in depth at the impact of peer labeling on juvenile delinquency. Qualitative methods were used to gain a better perspective on juveniles' decisions to engage in deviant behavior. The interviews conducted with the counselors served as raw data on the behavior of the juveniles whom they interact with daily. These results suggest that peers do impact each other's decisions when they begin to define their own social rules in

line with their own ideas, and as result, may not always find their behavior unacceptable. They will also participate in certain acts to receive acceptance from others, or to preserve their status within their peer groups, even if it means engaging in risky behavior. With these results, it is clear that in order to help prevent deviant behavior, the impact of peer pressure must be counteracted in some way. This research is somewhat limited due to the fact that counselors were interviewed rather than the juveniles themselves. The study can always be expanded through, conducting interviews with juveniles, focusing on specific age groups, as well as looking at other possible influences. Research like this can help continue to refine theories on deviance and shed more light on how juveniles interact and influence each other as they become adults.

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Student Perceptions of Poverty

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Summary of Research

Abstract

Efforts to understand poverty as well as how poverty is perceived have become increasingly important in the fight to eliminate poverty. This research investigated college student perceptions of people who are poor and how society and personal choices contribute to poverty in order to answer the following research question: How do student interpretations of issues surrounding poverty affect their attitudes, beliefs, and perceptions of poverty as well as those living in poverty? The study gathered perceptions about whom the students believe the poor to be, what circumstances have occurred, and what choices people have made that contribute to their being poor. Through quantitative methods, using a 64-item questionnaire originally used in a study by the Kennedy School, students enrolled in courses at Wichita State University provided data regarding their perceptions. The discussion identifies that perceptions are dependent on the economic class of the student, metro status, and level of education. Additionally, the results for the questionnaire will be discussed further.

Keywords: *Poverty, perceptions, Social Exchange Theory, Social Emotional Theory, stigma, attitudes toward the poor, recession, blame for poverty, responsibility.*

Introduction

For decades, scholars have engaged in efforts to understand the causes of poverty, how poverty is perceived, and how those perceptions aggravate or mitigate poverty (Cozzarelli, 2001; Wilson, 1996; Linda et al., 2009; Owen & You, 2009; Williamson, 1974). The number of people living in poverty increased from 46.2 million in 2010 to 48.5 million in 2011 (US Census, 2012). This research investigated college students' perceptions of people who are poor and how society and personal choices contribute to poverty in order to answer the following research question: How do student interpretations of issues surrounding poverty affect their attitudes, beliefs, and perceptions of poverty as well as those living in poverty?

Theories of Poverty

Social Exchange and Social-emotional theories are used to frame a discussion of perceptions of poverty, in addition to Maslow's hierarchy of needs. George Homans (1958), framer of Social Exchange theory, described the theory as a series of exchanges that people make in which they perform a cost-benefit analysis, seeking the most profit in terms of the social and relational world. People weigh the potential benefits and risks of social

relationships, and when the risks outweigh the rewards, people tend to terminate or abandon relationships (Emerson, 1976). Lange and James explained the Social Emotional theory by stating that "witnessing an external stimulus leads to a physiological reaction. Your emotional reaction depends upon how you interpret those physical reactions" (1967).

Abraham Maslow conceptualized a theory in 1943 that described human motivation in developmental stages represented by a hierarchy of needs. This can be applied in the study of poverty and perceptions of poverty, because people often view those who experience poverty as deficient in some way. Maslow's theory would assert that because their basic needs are going unmet, the poor remain paralyzed in accessing higher levels of experience and motivation (Maslow, 1970).

Methods

This research used quantitative methodology in order to produce generalizable statistical findings. The research procedures were formulated in advance and adhered to during data collection. The goal of the research was to gather college students' interpretations of issues surrounding poverty and their attitudes and beliefs about people who are poor, as well as society's role in poverty.

Instrument

The instrument that was chosen for this research was an adapted version of the NPR/Kaiser/Kennedy Study Poll on Poverty in America (2001). The questionnaire was designed to be anonymous.

Procedure

The survey was distributed to a cohort of convenience in two college classes: Women and Poverty and Political Science Model UN Human Rights, during the beginning of one class period. One hundred twenty-six students participated. It took approximately 45 minutes to complete. Beyond demographic questions, there were no specific identifiers of individuals. Results were analyzed using IBM SPSS software.

Results

Metropolitan status:

Urban	50.9%
Suburban	35.8%
Rural	13.2%

Education:

High school graduate or less	9.3%
Business, technical/vocational school graduate	.9%
Some college or more	72%
College graduate	10.3%
Post-graduate training	6.5%

Economic class:

Upper class	.9%
Upper middle class	8.4%
Middle class	33.4%
Working class	45.8%
Lower class	11.2%
Don't know	0%

How would you rate your financial situation?

Excellent	4.5%
Good	35.1%
Fair	48.6%
Poor	11.7%

Would you say you are doing well financially primarily because of our own effort and abilities, because of good luck, or because of things other people have done for you?

Own efforts and abilities	64.5%
Good luck	1.6%
Things others have done for them	33.9%
Didn't know	0%

Would you say you are not doing so well financially because of something you yourself have done or failed to do, because of bad luck, or because of things other people have done for you?

Something they have failed to do	60.3%
Bad luck	17.9%
Things other people have done	22.1%

In your opinion, which is the bigger cause of poverty today— that people are not doing enough to help themselves out of

poverty, or that circumstances beyond their control cause them to be poor?

People not doing enough	21.1%
Circumstances	64.2%
Don't know	14.7%

Is poor people lacking motivation a major cause of poverty, a minor cause, or not a cause at all?

Major	24.8%
Minor	44%
Not a cause	26%
Didn't know	4.6%

Discussion

Financial situation

As indicated from the responses to the questionnaire, over half of the respondents identified as working class or lower (57%), showing that they are experiencing or trying to work their way out of poverty, possibly through earning a degree or, in the case of 6.5% of the respondents, pursuing graduate studies. This majority of lower-class respondents could have potential effects on all of the data, as they have all been close to or actually in poverty. It is hard to understand poverty without experiencing it.

Success and Dependence

A majority of the respondents (64.5%) of this study indicated that their success was based on their own efforts and abilities. Metropolitan status, economic class, and education might have influenced the answers to the study. Specifically, respondents were all students who lived in the state of Kansas, so they may depend on their family for help. The second factor to be considered is the economic status of the respondents. The percentage of respondents who identified with the upper class status was only .9%. The rest may feel they have to earn their own way.

Failure and Dependence

Sixty percent of respondents took responsibility for their own failures. It is possible that education, metropolitan status and economic status have a lot to do with their responses. Most of the respondents can be said to have experienced poverty themselves or know people who live in poverty, with 57% identifying as working class or lower. As a commuter college, with 50% of students coming from urban areas, it is possible that these students are presented

with more employment opportunities, and therefore believe they have a greater ability to further their financial status. Another possibility is that, considering that the survey was also given to two classes that might have a better understanding of poverty, this could have impacted their answers. Some respondents (22.1%) also gave credit to others for their success. This could be due to the fact that most respondents were students who may still live with their parents and receive support from them.

Circumstance of Poverty

An overwhelming 64.2% of respondents believed that circumstances had a huge impact on a population's economic status. This could be because all of the respondents were students who could be experiencing financial difficulty, as well as the fact, noted above, that they may be more dependent on others for financial success.

Poverty and Motivation

The majority of respondents (26%) gave the poor the benefit of the doubt by saying that lack of motivation is not a major cause of poverty, even while they blame themselves for their own circumstances. This notion can be explained by looking at the charts for metropolitan status, education and economic status.

Limitations and Further Research

The sample is not representative of the population as a whole, preventing generalization at large. Limitations include sample cohort, as there are distinct populations (college students) who enroll in these types of courses. Future research should explore other populations.

Conclusion

Wilson (1996) identified the indirect and direct impact of how a culture perceives the poor, pointing out that perceptions can be advantageous or harmful depending on how individual beliefs develop. Some participants in this study put the responsibility for poverty with the poor themselves, a belief that is potentially harmful to the poor. Understanding these perceptions and beliefs can help in creating a world where the effects of poverty are minimized and the poor are helped and, more importantly, understood. The study concludes that perceptions are dependent on the experiences, background, and social class of the student, highlighting this issue's complexity.

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The Development of an Electronic Alert and Monitoring System for Use on a Bio-Sand Filter
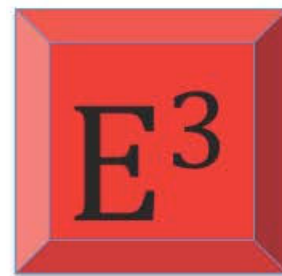
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Summary of Research

Abstract

Biosand filters are point-of-use filtration systems that remove pathogens and suspended solids from water. They are commonly used in developing countries, as they can be constructed from readily-available materials and do not require chemicals or electricity. Compared with other point-of-use filtration systems such as chlorination, however, biosand filters require continual maintenance to be effective. Moreover, when communities are introduced to biosand filtration, it can be challenging to assist them in developing habits, which support the necessary maintenance. To address these issues, a microcontroller-based, battery-powered training and monitoring system, which uses LEDs to notify users when to perform maintenance tasks, was developed. Two sensors ensure that the tasks are completed. The microcontroller also captures this data for future review. This project is awaiting field trials, which will measure its effectiveness. Proposed methods for testing the device will be discussed.

Introduction

There exists an increasing need to develop methods of water treatment that are within the reach of developing nations. This necessity is seen by the number of people around the world who are afflicted with illnesses associated with poor water quality. According to The United Nations Children's Fund (UNICEF), 4,000 children die each day due to such preventable diseases.[2] The various methods of water treatment can be divided into three categories: sedimentation, disinfection, and filtration. Sedimentation involves allowing the water to sit for a period of time so that the suspended particulates settle to the bottom of the container. The less turbid water is then decanted out. This method is usually used in conjunction with one of the other methods mentioned, as particulate and pathogenic removal is not complete. Disinfection is used to remove the dangers that are less visible to the human eye and which pose the greatest threat. This method can be implemented through either boiling the water or the use of chemical additives. These additives can serve various functions, such as chlorine's ability to kill off harmful biological contaminants and coagulants that can aid in the sedimentation process by promoting the combination of small suspended particles into larger ones, allowing

them to settle more quickly. Though these methods allow for almost complete removal of pathogens that cause illnesses, they often prove to be resource intensive, imposing an ongoing financial cost (importing the necessary chemicals that would be involved, such as chlorine, or high energy requirements, as there are in boiling). Filtration requires that the water be passed through some mechanism that has the ability to remove contaminants. The removal process can be effective against suspended particles as well as various pathogens and chemicals that may have been introduced into the source water, though the processes often do not result in complete removal and require periodic maintenance to ensure filter effectiveness. Hokanson et al., suggest that the best treatment technology for developing rural areas is filtration.[7]

More specifically, this study focuses on the Bio-Sand Filter, which can be constructed with materials that are often found with relative ease throughout many regions. The defining function of the Bio-Sand Filter that sets it apart from other filtration systems is the cultivation of a bacterial layer that develops to feed on the specific biological contaminants that are found in this particular source water. In order for this, the water must pass through a volume of sand that is roughly 54 cm deep. The biological layer develops within the first few centimeters of this sand layer. This filter has been shown to remove up to 98.5% of bacterial contamination from the source water when implemented in the field.[8] Furthermore, Stauber et al., had conducted a study of the effectiveness of the Bio-Sand Filter to reduce the diarrheal disease burden in the Dominican Republic. A mixed sample of 154 households – 75 of which had been given a Bio-Sand Filter at the start of the study – were monitored over the course of 6 months. Their results showed that the households who had operated the Bio-Sand Filter had instances of diarrhea reduced 53% compared to the control group that did not operate a Bio-Sand Filter.[9] This is important because diarrhea has been shown to be the second leading cause of child mortality globally, and 85% of the global diarrhea burden can be attributed to poor water sanitation and hygiene.[4,5]

In order to maintain the effectiveness of the Bio-Sand Filter, the water level above the sand cannot go beneath or remain above 5 cm from the top of the sand layer, the filter must be run at least once in a 48 hour period, and it must not be run again for at least an hour after it has finished. This is to ensure that the biological layer is able to sustain itself. If the water drops beneath 5 cm, the risk of the biological layer drying becomes a concern; too long above 5 cm and the layer runs the risk of suffocating; if the filter isn't used at least once every 48 hours, there is a risk of the layer dying of starvation. This study seeks to answer the questions regarding the extent to which maintenance habits affect the quality of the treated water, and to determine the ability of an electronic training device to reinforce such habits. The training device attempts to provide real-time feedback to the users regarding the state of the filter in an attempt to increase the likelihood that the necessary maintenance steps are taken. Furthermore, the device is able to record the frequency that certain maintenance practices are performed, as well as the state of the filter itself by merely monitoring the level of the standing water. The expectation is that, upon subsequent visits by the group who sought to implement the filter, detrimental habits can be addressed by looking at the users' maintenance history stored on the device.

Proposed Methodology

The proposed research will look at the effectiveness of this training device in preventing the development of detrimental habits and its ability to reinforce awareness of the filter's maintenance requirements. After doing so, it will look at the trend in water quality associated with an increased adherence to the required maintenance regimen. It will do this by designating 3 groups: Group 1 will be given the fully functioning system along with the filter, Group 2 will be given a filter along with a limited functioning system that only logs stateful events but does not alert the user as to what actions to take, Group 3, the control group, will receive only the filter. Preliminary surveys detailing the average condition of the source water for each group will be conducted to compare contamination levels between pre-implementation and post-implementation. Once installed, the groups will be visited once every four months over the course of a year. The reason for the four-month gap is an attempt to observe how behaviors change over extended periods of time without observation. During these visits, each group will be given a survey intended to gather information regarding their overall

disposition toward the filter. This information will be used to determine whether the presence of the alert system has an effect on how the filter is viewed and if there is a correlation between this and maintenance habits. While there, samples of the water passed through each filter will be taken, and data regarding maintenance habits from each system will be recorded. After the year period, the systems will be returned, but the groups will keep the filters.

Once all of the data has been recorded, comparisons between the groups will be made. A comparison of the data from groups 1 and 2, specifically the information logged by the system, will be made. This comparison will determine the effectiveness of a visual reminder to promote proper maintenance habits. If the system aids in the development of proper maintenance habits, then Group 1, with the fully functional system, will have, on average, fewer instances of prolonged periods of non-use as well as fewer instances of reduced water level than Group 2.

Following this, a comparison of the post-implementation water-quality over time for each group will be made. If each group acquires their water from different sources, a comparison between post-implementation water and source water will be made to determine the filters' relative effectiveness, and the results will be normalized over all three groups to allow for accurate comparison. If proper maintenance habits impact the effectiveness of the filter to remove contaminants, and if the system has been shown to aid in the development of these habits, then Group 1 should, on average, have had a greater success in removing contaminants from their source water than the other two groups.

A third and final comparison of post-implementation water quality will be taken, specifically focusing on Group 2 and the control group. This comparison is intended to determine what effects the mere presence of the system on the filter has on maintenance behaviors. If the effectiveness of Group 2's filters are significantly higher than that of the control group, it may be that the feeling of constant observation promotes the necessary behaviors. If this is the case, a comparison between the effectiveness of Group 1 and Group 2's filters must be taken to determine if the visual reminders of the fully functional system contributed to the increased effectiveness.

Conclusion

The health impacts that untreated water can have on a person can be lethal. With a sizable portion of the global population suffering from a lack of treated water, it is imperative that a sustainable means to provide such treatment be introduced into those regions that are affected. The use of the Bio-Sand Filter is one such means. Its effectiveness in removing bacteria that cause illnesses, along with the relative abundance of the material components, makes it an ideal method for many areas. This study aims to understand the effects appropriate maintenance habits had on the resultant water quality. This will be achieved by implementing an electronic device to monitor maintenance trends and to train the user in appropriate behaviors. It is anticipated that a correlation between maintenance habits and water quality will be revealed.

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Adjustments in Study Abroad Requirements for U.S. Higher Education System Are Needed to Increase College Students' Bi-sensibility

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Summary of Research

Abstract

Current foreign language requirements at North American colleges, specifically in the Midwest, do not adequately prepare students to use another language in a globalized world. This paper will discuss the current problems in study abroad programs that hinder the benefits study abroad can offer psychologically, sociologically and linguistically for students. Study abroad should focus on enabling students to become "bi-sensible" citizens of the world. Bi-sensible citizens acquire a new perspective from a culture not native to their own. This level of exposure requires the student to live in the culture and it is not equivalent to a classroom experience. Secondary and primary sources will be used to complete this extended literature review.

Introduction

Studying abroad is one-way students can increase their cultural and linguistic competence. Unfortunately, there are gaps in current study abroad requirements at North American universities that may hinder students from becoming bi-sensible citizens. Consistent gaps identified include the absence of cultural orientation before and after the sojourn, the lack of academic requirements while abroad, and a lack of required language use, with other students or host nationals. In addition, research has shown that males and minority students are under-represented in study abroad programs, possibly due to a lapse in marketing. These issues are explored through the use of primary and secondary literature, and suggested improvements are offered based on the data presented, such as exposing students to foreign cultures at younger ages and altering study abroad marketing techniques to reach a more diverse audience. By addressing these issues, programs can help students by giving them the tools to become bi-sensible.

Defining Bi-sensibility

Texas Chicano poet Tino Villanueva describes bi-sensibility or *bisensibilismo* as "the experiencing of something from two points of reference," or two alternative viewpoints, in his article, "Language Choice in Literature." Bi-sensibility is bicultural and bilingual fluency attained by exposure to a language's culture. Students cannot become bi-sensible, global citizens in a classroom in the United States surrounded by students of their same race and culture. Esmeralda Santiago, a bilingual author from Puerto Rico, is a good example of bi-sensibility: she writes in English and thinks in Spanish. Santiago believes both languages enhance her cultural identity. She writes, "The world is moving toward forming partnerships, and we are enriched by feeling that we can have two cultures. Without losing our roots, we can understand and celebrate other cultures. We are more complete individuals—adding, not subtracting" (Bianco, 62). For this research, study abroad is defined as the pursuit of educational opportunities and activities in an international setting (Study Abroad Administration). Although students can benefit from cultural experiences in diverse populations in their community, this research will focus on the effects of international exposure. Both secondary and primary qualitative data were gathered to complete the extended literature review.

Adjustments in Study Abroad Requirements

Elements like orientation and cultural exposure are important for students' bi-sensible growth while abroad and are consistently missing in study abroad requirements at universities across the nation. The data, gathered from the websites of 12 universities, represent a wide geographic and diverse population. A reoccurring theme in the data was the absence of orientation, academic rigor and language proficiency. Jane Jackson highlights in her study that, "in order for students to understand their experience fully, there needs to be reflection before the trip, as well as similar exercises during and after." According to their websites, five of the 12 universities require orientation before the sojourn, and none of the universities require orientation after or during. Kevin W. Dean and Michael B. Jendzurski discuss how programs fall short when it comes to post-travel orientation and evaluation (102). The majority of the universities evaluated also do not require enrollment in a university abroad, daily assignments or scheduled time with host nationals. Michael Vande Berg, R. Michael Paige and Kris Hemming Lou report that students should study language for longer periods of time, live with host families, enroll in university courses and spend free time with host nationals (17). They also suggest, that "students [be] provided with a series of assignments each week that are designed to stimulate engagement with the host culture" (348). Addressing these issues could increase the retention of information students bring back after their travels.

Reflection is important after a student decides to study abroad, not only to aid in implementation of their trip, but also to gather data on the effects of foreign travel on the student. In order to have efficient data, researchers need more students to evaluate. A NAFSA: Association of International Educators study in 2010-2011 reported that 1% of U.S. College students had studied abroad that year. In 2009 and 2010, the U.S. ranked the lowest of all continental regions for the amount of students studying in other countries, and 77.8 % of the students who do participate are Caucasian. Further research could help programs understand the reasons some students do not participate in study abroad. Three gaps in current research are grade school exposure, minority and male participation.

Foreign language learning "should come early…because the young child learns a foreign language with ease and pleasure," (*Securing America's Future* 101). If young students are exposed to culture early, they might be more interested in study abroad when they are younger. Students familiar with a language or a culture when they are younger might grow up with a heightened sense of cultural competence and curiosity. Horace Mann Dual Language Magnet School in Wichita, Kansas incorporates culture and language into their school curriculum. According to the website, the school mission statement is, "to establish a strong, standards-based curriculum, which promotes high academic achievement in both English and Spanish, in an environment that embraces diversity and strives for excellence." The students learn how to read, write and communicate in Spanish and English. Bilingual schools are an example of early exposure to language and culture for young children.

Study Abroad and Minority Students

White students comprise only 60% of university enrollment, but 80% of study abroad participation according to *The Seattle Times* journalist Kathy Matheson. Minority students may face different challenges than white students when it comes to studying abroad. Many times minorities are unaware of the opportunity to study abroad (Matheson), or are afraid they will face discrimination and prejudice, according to an article, "Changing the Face of Study Abroad" by Ingrid Norton. In addition, programs may not address the specific needs of minorities or include their demographics in promotional material, making them feel that studying abroad is "reserved for white people" (Norton). The University of Pittsburg found a solution to this problem when they increased the diversity of their employees. However, participation of black students rose by 15%.

Study Abroad and Gender

A study done in 2006-2007 by Elizabeth Redden, "Women abroad and men at home," said more than 65% of study abroad participants were women. Females have historically represented study abroad, which can send the wrong message to many men. James M. Lucas, of Michigan State University, said, "Women were sent overseas to be culturally educated ladies who could entertain their husbands' business partners" (Fischer, 1). This historical process has perpetually made studying abroad a feminine act. It has been reported that with nearly 1,300 students studying abroad, women gain more from more culturally and linguistically than men (Fischer, 3). Further research could shed knowledge for programs to better serve the needs of males abroad.

Conclusion

Bi-sensibility benefits students' individual, cultural and linguistic competence, and it consequently helps society. Studying abroad gives an opportunity to contemplate life outside of the usual limits and boundaries of their country, challenging opinions and teaching effective communication in uncomfortable circumstances. Although study abroad is not the only means by which a one can attain bi-sensibility, it conveniently incorporates language and culture in an academic setting. If programs address the current gaps in study abroad requirements and incorporate new ways to increase awareness, students might have

a better chance of becoming bi-sensible citizens.

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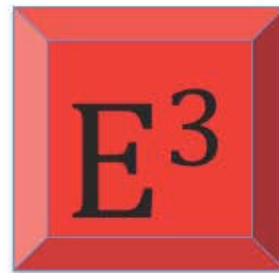
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Summary of Research

Abstract

As society changes and develops, and technology continues to play an increasing role in everyday life, many school districts are choosing to respond to this flow of digital information. The use of courseware to support teachers and students has emerged, and the number of distance-education programs or online virtual schools has grown rapidly in recent years. Attempting to fill the gap between traditional education and home-based schooling, these online schools work to provide parents and students with a variety of viable options that include structured curricula, pacing guides, and numerous course offerings at scheduled or unscheduled times. The purpose of this study was to define virtual schools and identify a variety of options. After a review of the literature, researchers completed a comparison study between different virtual schools and programs primarily focused near metropolitan areas in one midwestern state, looking at the structure, student population, and use of each school/program to identify trends. This research encompassed secondary qualitative data gathered from the school/programs' virtual handbooks and websites. Both a comparative descriptive research design and qualitative analysis were used to categorize and compare data.

Keywords: online school, online program, virtual education, distance learning, choice

Introduction

Many school districts currently include a distance-education program in their offerings to students. According to the National Center for Education Statistics (NCES), distance education courses are "courses that are credit-granting, technology-delivered, have either the instructor in a different location than the students and/or have the course content developed in, or delivered from, a different location than that of the students" (U.S. Department of Education, 2012, p. 1). This growing class option has, in many cases, morphed into entire clusters of education programs being offered online, often called virtual schools. Most commonly defined as "an entity approved by a state or governing body that offers courses through distance delivery – most commonly

using the Internet," virtual schools have become the norm in some parts of American education (Barbour & Reeves, 2009, p. 402). As a precursor to answering questions about why students are electing to attend virtual schools and whether or not they are finding success in these environments, an exploration of a few virtual schools and programs in the area focused on the structures, levels of students, and offerings. Through a review of the literature and a comparison study of a small number of virtual schools and programs in the Midwest, this research seeks to understand the inner workings of online education.

Review of the Literature

Instructional Options

Although virtual schools tend to have many traditional elements such as administration, staff, curriculum, parent conferences, special education, and sometimes even field trips, they are original in the way they provide instruction. In general, there are three main categories that define the way a virtual program is run: (1) independent, (2) asynchronous, (3) synchronous (Barbour & Reeves, 2009). Independent environments typically include students teaching themselves the material with parental supervision and minimal teacher involvement. The asynchronous method requires the student to interact with the curriculum and requires the teacher to be more involved in providing feedback and formative performance evaluations (Barbour & Reeves, 2009); however, the teacher and the student will not meet together in a classroom environment. Lastly, the synchronous method attempts to recreate an authentic classroom environment for the online community of students and teachers.

Student Population

Despite the numerous schooling methods, staff and student personalities may play a role in the success of virtual school students. According to Roblyer and Marshall (2003) (as cited in Davis & Roblyer, 2005), "students who have been successful in traditional classrooms are not always as accomplished in virtual ones" (p. 400). Distance education allows school districts to meet the needs of certain student groups, including those who are driven to take Advanced Placement (AP) and college-level courses, who are hospitalized or homebound, who have been removed from the school for reasons of suspension or incarceration, or who tend to travel due to athletics or

family situations (p. 407). Online programs can also support homeschooled students and their families. Lastly, virtual schools have been a viable option for students who were not previously successful in traditional environments, as well as students wanting to supplement their current curriculum with a variety of course options (Barbour & Reeves, 2009, p. 408).

Methodology

Virtual Schools and Programs

In Kansas, virtual schooling can take two avenues. Districts that have a separate administrative staff for the entity, and elect to have it in a separate "building," are called virtual schools. The districts that support students and families within their existing school structures are titled virtual programs. A comparison study was conducted using two virtual programs and three virtual schools within the state of Kansas to determine similarities and differences between the five schools/programs, as well as to determine similarities and differences between traditional and online schooling. Online searches of Kansas virtual schools were used to identify the websites. Schools and programs were chosen based on their location in Kansas, connection to an accredited school district, and their use of a detailed website that would provide relevant data to the researchers. Three virtual school websites and two virtual program websites were identified for use in this comparison study.

Virtual programs. Maize Virtual Preparatory School, an online program within the Maize Unified School District 266, offers students in grades K-10 a blended program that features both traditional and virtual instructional elements. iQ Academy Kansas, a fully-accredited virtual program, housed within the Manhattan-Ogden Unified School District 383, offering students in grades 7-12 a STEM+ (science, technology, engineering, mathematics) curriculum focus.

Virtual schools. Lawrence Virtual School and Lawrence Virtual High School are both publically-funded schools, within the Unified School District 497, Lawrence Public Schools, offering students in grades K-12 a flexible online experience. Learning[2] eSchool of Wichita, an accredited public school, within Unified School District 259, Wichita Public Schools, provides grade-specific offerings to K-12 students. Insight School of Kansas is an accredited

virtual high school, housed within Spring Hill Unified School District 230.

Procedures

The procedures closely followed a comparative descriptive research design. Qualitative topics for investigation were generated from links on the webpage. The information found on these sites was instrumental in the construction of a table of information that informed the study.

Data Analysis

Results were analyzed using a qualitative analysis, categorizing the data found on the virtual websites into sixteen general themes. From there, the researcher was able to identify overlap between the various schools and programs. Looking at these general themes, the researcher pinpointed specific similarities and differences noted in the data, creating categories of comparison.

Using this process, the main elements identified were (1) demographics, (2) curriculum, (3) school/program format and instruction style, (4) enrichment and social interaction, (5) eligibility and enrollment, (6) technology and materials, (7) support teams, (8) time requirement, and (9) recruitment.

Results

Sixteen categories emerged to provide the researchers with a basis for comparison. In general, there are many similarities in tuition, technology and materials, social interaction, and course offerings.

After categorizing website findings into a table of information, researchers found that 11 of the 16 variables contained some information from all five schools/programs. The remaining five variables were present in at least one of the schools/programs but not all five. Basic demographic information can be represented by four of the 11 variables: accreditation, tuition, dual-enrollment, and grade level. All five virtual schools/programs, although varying in grade level offerings, host tuition-free programs for Kansas residents. Curriculum composes a large part of the collected data, and it appears that many of the school districts have adopted outside curriculum packages. These include Calvert, STEM+, APEX, and K12. Three of the five schools/programs speak of a

blended school format where students complete assignments and learn both online and offline. The other two schools/programs seem to have a completely computer-based curriculum. All five virtual schools/programs are intentional about hosting face-to-face opportunities for social interaction and academic enrichment. Field trips and local outings/events are found within each virtual school/program's schedule. All schools/programs specifically note that virtual teachers are licensed and experienced. Virtual school/program teachers are readily available to help students and parents via numerous avenues of communication. All of the virtual schools/programs identify parents as learning coaches or supporting guides. The time requirement for a virtual school/program student was mentioned by four of the five schools/programs. Although time will be influenced by a variety of factors, on average a student needs to spend between four and six hours on school work per day. Recruitment is loosely used to categorize information found on the websites that identifies the types of students that attend the virtual school/program or why students should attend the virtual school/program. Four of the five schools/programs identified homeschooled families or families who would like to be actively involved in their child's education as possible future students.

Discussion

After reviewing the research in virtual education, this comparison study set out to identify similarities and differences in the 16 variables previously mentioned. The high number of options available within the different virtual environments allows students choice and ownership within their education program. How schools/programs offer their curriculum must be considered: two-way video conferencing is common within smaller school districts and web-based learning is more common in larger districts, but the number of communication options has increased as virtual schools have evolved. Field trips, activities, programs, and enrichment options allow students time to interact in social groups with students much like themselves. Most of the schools/programs seem to use an asynchronous approach, but elements of independent and synchronous approaches can also be seen. It is important that students consider their personality before attending a virtual school due to the individual and self-paced nature of the curriculum.

Conclusion

In conclusion, virtual schools provide families and students choices within their educational environments. They have the opportunity to tailor a program to fit their personal goals and needs. Through various instructional techniques and a guided and structured curriculum, students can accept greater ownership of their educational experiences than they might in a curriculum narrowed by geography. Encouraging alternative educational models allows families and students to match their education to their wants, needs, styles, and capabilities. Virtual schools grant families choices related to the education of their children, allowing their child to be *home*schooled with the presence of a licensed teacher and support staff. Overall, virtual schools provide parents and students with the option to make informed choices about their own educational experience, all while creating an individual plan for learning and success.

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