CHOOSY NEWTS AND CLASSROOM SNAKES: A NON-TRADITIONAL EXPLORATION OF ONTARIO AMPHIBIANS AND REPTILES

By

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To my family

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LIST OF ABBREVIATIONS

ºC	degrees Celsius
ANOVA	analysis of variance
CV	coefficient of variation
dpa	days post amputation
DSBN	District School Board of Niagara
EE	environmental education
EFN	Education Foundation of Niagara
Fig	figure
hr	hour
ID	Instructional Design
LSD	least significant difference
min	minute
NAAEE	North American Association for Environmental Education
ON	Ontario, Canada
PCHS	Port Colborne High School
Q&A	question and answer
SME	subject matter expert
UNESCO	United Nations Educational, Scientific, and Cultural Organization

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Amphibians and reptiles have long been the subjects of scientific research in diverse fields such as medical and embryological biology, physiology, ecology, biotechnology, evolution, and genetics. Yet, the future of amphibian and reptile research is uncertain. Amphibian and reptile populations are declining globally, with many, if not most causes either directly or indirectly related human behavior including climate change, pollution, road mortality, intentional killing, and commercial harvest. This study combined traditional scientific research with environmental education (EE), two fields that are mutually dependant on one another. EE must promote public awareness and knowledge using the findings of scientific research while researchers depend on successful EE for the sustainability of their model organisms.

First, I examined the effects of small changes in environmental temperature on the rate of forelimb regeneration in the red-spotted newt (*Notophthalmus viridescens*). Newts are small ectotherms that are aquatic as adults; as ectotherms they naturally conform to the temperature of their surroundings. Rate of regeneration was temperature dependant and increased with increasing temperature. Yet, when given a choice of environmental temperatures, regenerating newts consistently behaviorally

thermoregulated around a narrow temperature range that was lower than the temperature which maximized rate of regeneration. Uninjured newts did not demonstrate such rigid thermoregulation, suggesting that maintaining a stable temperature preference may be more important to regenerating animals.

Continued research on amphibians and reptiles depends on stable populations. Therefore, it is important for EE to facilitate people to change their negative behaviors which threaten wildlife to ones that are conservation oriented. Young & Wild was a new after-school program which trained secondary students to deliver reptile educational outreach to community audiences. Presented in this article is a model of this new educational outreach training program, suitable for integration into an environmentally oriented camp environment. The training program design includes an information session, presenter handbook, group practice sessions, and presenter evaluations. Attention is paid to requirements, challenges, and revisions based on formative and summative evaluations. Continued implementation of EE programs like Young & Wild will hopefully contribute to stable amphibian and reptile populations for future generations to complete scientific research and experience these animals in their natural ecosystems.

CHAPTER 1
INTRODUCTION

Amphibians and reptiles have long been characters in stories, myths, and legends: kissing princesses, slowly and steadily winning races, and promoting forbidden fruits. These animals have captivated people's wonder and imagination, and with good reason. There is a great deal of knowledge that can be unlocked by studying amphibians and reptiles.

Amphibians have historically been used in medical and embryological research. In 1768, Spallanzani was the first to report spinal cord regeneration in adult newts, and in 1888, Roux published experiments on frog embryos. Research using amphibians has contributed to the development of reliable pregnancy tests (Gurdon and Hopwood, 2000) and new antibiotics (Stone et al., '92; Steinborner et al., '98); while future areas of research include treatment of ulcers, cartilage repair, heart disease, and painkillers (Chivian and Bernstein, 2008). Similarly, components of snake venom have been shown to inhibit human cancers (Trikha et al., '94; Markland et al., 2001; Swenson et al., 2004). Researchers have been studying snake venom for over 50 years and are continuing to find new compounds (Roy and Kini., 2010). From a physiological point of view, amphibians and reptiles have intriguing abilities. Some turtle and frogs are freeze tolerant, amphibians and turtles can breathe through their skin, and some frogs produce a natural glue (Wang et al., '89; Clarke, '97; Packard et al., '99). The unique physiologies of these animals have created excitement for the future development of new biotechnologies (Clarke, '97; Wendell et al., 2010).

Yet, more important than these animals' potential benefits for medical and technological advances are amphibians' and reptiles' places in their natural ecosystems. They are predators and prey, detrivores, symbionts, and are vital elements in the web of life. Unfortunately, both amphibians and reptiles are facing global declines and many, if not most, of the causes are directly or indirectly related to human behavior. Pollution, habitat loss and degradation, road mortality, intentional killing, and commercial harvest have all been linked to amphibian and reptile declines (Gibbons et al., 2000; Collins and Storfer, 2003; Sodhi et al., 2008). The goal of environmental education (EE) is to help people become environmentally active citizens, to facilitate changes in people's behavior from environmentally destructive to conservation oriented (UNESCO, '78; Peters and Matarasso, 2005). This process is achieved by teaching the public about the values of the environment and biodiversity and giving people the knowledge and skills to become environmentally active through education, research, and conservation/restoration programs (Palmer, '98).

It is essential to combine research and EE because these two fields depend on each other. Environmental educators must present the most up-to-date facts on species at risk and environmental issues to the public to promote awareness and knowledge which help form people's attitudes and behaviors (Jacobson et al., 2006). Similarly, researchers depend on successful EE so that the knowledge, ecological insights, and medical as well as technological advances these species hold can continue to be gained by future generations. Thus, presented in this work is research on limb regeneration in the red-spotted newt as well as a new model of youth-led EE. Research in these two seemingly distinct fields will hopefully support future generations' fascination and curiosity for amphibians and reptiles.

CHAPTER 2
FORELIMB REGENERATION AND TEMPERATURE PREFERENCE IN THE RED-SPOTTED NEWT *NOTOPHTHALMUS VIRIDESCENS*

Introduction

Although urodeles (salamanders and newts) are often touted as champion vertebrate regenerators, with the ability to replace lost limbs, tails, jaws, spinal cords, and the lens of the eye, studies have found a great deal of variation between, and even within urodele species. Notable variation in the ability to regenerate (Scadding, ‘77, ‘81), the rate of regeneration (Sessions and Larson, ‘87), and the presence of abnormalities (Stock and Bryant, ‘81) leads one to question what causes variation in regeneration. Even the red-spotted newt (*Notophthalmus viridescens*), a common model species for regenerative research, has shown considerable intraspecific variation. Pritchett and Dent (‘72) found an inverse relationship between body size and rate of regeneration in the red-spotted newt, with larger animals regenerating more slowly. The authors concluded that the distribution of nerves and the age of animals may be contributing factors. Scadding (‘77, ‘81) also found a similar inverse relationship between body size and regeneration across urodele species, in which small species regenerated well while large species produced heteromorphic limb buds or failed to regenerate at all.

Interestingly, environmental temperature appears to be a more striking source of intraspecific variation in red-spotted newt regeneration. These animals are small ectotherms that are aquatic as adults, thus conforming to the temperature of their surroundings. Temperature alters rates of biochemical reactions in ectotherms, affecting physiological functions such as muscle activity, digestion, and wound healing. Schauble and Nentwig (’74) found that rate of regeneration increased with increasing temperature, with low temperatures (10 ºC) nearly inhibiting regeneration. These findings are similar to thermal effects on limb regeneration in fiddler crabs (*Uca pugilator*). Weis (‘76) found that 16 ºC was cold enough to inhibit fiddler crab limb regeneration, while 30 ºC greatly accelerated regeneration. Schauble and Nentwig (’74) explored temperature’s effects on newt regeneration by examining both rate of growth, and rate of differentiation. Rate of growth measured the amount of new tissue produced from regenerating forelimbs over time, while the rate of differentiation measured the animal's limb morphology on a scale from 1 (wound healing) to 13 (completed differentiating). They found that 25 ºC lead to maximum new tissue growth while 30 ºC maximized the rate of differentiation. This disparity between optimal measurements of rate of regeneration lead the authors to question whether a temperature between 25 and 30 ºC would maximize both the rate of growth and rate of differentiation simultaneously. In this study, I further examine the effects of environmental temperature by focusing on smaller differences in environmental temperature. I hypothesize that even small increases in environmental temperature (2 ºC) will continue to lead to increases in the rate of regeneration, with a maximum rate falling between 25 and 30 ºC. The results of this study may inform future laboratory studies of regeneration as well as evoke further interest in investigating the behavioural mechanisms of thermoregulation.

In the wild, the red-spotted newts' habitat range covers a wide latitude from the Canadian Maritime provinces through the Great Lakes down to Georgia and Alabama (Conant and Collins, ’98), exposing populations to varied thermal climes, especially in northern ranges where air temperatures change from below freezing in the winter to warm summer temperatures which can rise above 30 ºC. Like many ectotherms, red-spotted newts will use behavioural mechanisms to maintain a preferred body temperature. Berner and Bessay (2006) found that red-spotted newts from a population in Tennessee selected warmer environmental temperatures in the summer (27 ºC on average) than in the winter (17 ºC on average). Temperature preferences also correlated with seasonal biochemical changes. A relationship between biochemistry and behavioral thermoregulation in red-spotted newts was further supported by the continued work of Berner and Puckett (2010) who found that newts acclimated to summer and winter conditions were able to change standard metabolic rate, preferred temperature, and the activity of some oxidative enzymes in a complimentary manner. However, it is unknown whether injury and subsequent regeneration affect newts' thermal preferences. Studies on tail autotomy in lizards have found that animals regenerating autotomized tails do not have altered temperature preference in a thermal gradient or different field body temperature than tailed lizards (Chapple and Swain, 2004; Herczeg et al., 2004). However, regenerating lizards alter microhabitat use and basking behavior in the wild, opting for longer basking periods closer to refuge as a means of maintaining thermoregulation (Martín and Salvador, ’93). Forelimb amputation in urodeles initiates a signal cascade which coordinates wound healing, immune response, cell proliferation, and cell migration (Roy and Levesque, 2006). Since thermoregulation is often altered by different immune states through neuronal or hormonal substrates (e.g. TNF-a, IL-6; Bicegeo et al, 2007), we predict that red-spotted newts will alter their thermal preference while regenerating, selecting a temperature which maximizes the rate of regeneration. Additionally, based on the premise that increased metabolic activity accompanies local tissue regeneration, we examined the thermal condition of regenerating limbs to determine whether wound healing and subsequent regeneration augments forelimb temperature.

Materials and Methods

Animals, Husbandry, and Forelimb Amputation

Sixty-four adult Red-Spotted Newts (*N. viridescens*) were supplied from Boreal Labs (St. Catharines, ON) between May and July of 2009. Animals were identified using individual spot patterns, and mass (ranging from 0.71 to 3.08 g) and snout-vent length (ranging from 30.71 to 44.69 mm) measurements were taken. Newts were housed in rectangular plastic containers with perforated plastic lids (4-5 animals per container). Containers were lined with damp paper towel, half-filled with dechlorinated water and angled to provide newts a choice of being in or out of the water. Newts were fed frozen brine shrimp by hand, which they ate readily, *ad libitum* three times per week for the duration of the experiments. Tanks were cleaned following feeding. A 12:12 hr light/dark cycle was maintained. Newts were given a minimum of one week acclimation prior to forelimb amputation.

Animals were anaesthetized in a bath containing 0.1 % MS-222 (Sigma) in dechlorinated water (pH 7.0). Right forelimbs were amputated through the midradius/ulna and protruding bones trimmed to the level of the soft tissue. Newts were placed in an ice bath until bleeding significantly slowed or stopped (~10 min). Animals were then placed in the small, angled plastic containers on damp paper towel and monitored until recovery from anesthetic was evident. All protocols were approved by the Brock University Animal Care and Use Committee.

Effect of Temperature on Rate of Regeneration

Upon arrival, 40 newts were separated randomly into four temperature groups (23, 25, 27, 29 º C) and housed in separate plastic containers. A coin was flipped twice to determine group: heads-heads was 23 º C, heads-tails was 25 º C, tails-heads was 27 º C, and tails-tails was 29 º C. The containers were kept within one of four diurnal growth chambers (Thermo) set at 23, 25, 27, and 29 º C. Temperature within the growth chambers fluctuated by about ± 0.1 º C. Each diurnal growth chamber housed 10 newts. Newts were given one week acclimation within the diurnal growth chambers prior to limb amputation (see above).

To image newts' regenerating limbs, animals were individually positioned with their right forelimbs flat against the bottom of a glass petri dish under a dissecting scope (Leica MS5). Newts were gently held in place by their tails, with no anesthetic used to sedate the newts. Newts were initially cooled for ~20 minutes prior to imaging. However, mortality in several newts lead to the termination of this practice. It is uncertain whether the death of these animals was linked to thermal stress, but the death rate decreased after the cooling period was removed. A lack of sedation or cooling initially resulted in increased handling time to capture images. However, after 30 days of imaging, when being gently held on the petri dish by the tail, all newts in this study would place their regenerating forelimbs in a desirable position to be photographed. This greatly reduced the handling time of newts, demonstrating that newts can be trained to cooperate for imaging without the use of anesethetic or cooling. A grid (0.5 cm x 0.5 cm squares) was placed under the petri dish as a known measurement. Photographs of regenerating limbs were taken with NIS Element (F 3.0) using a microscope camera (Nikon Digital Sight DS-Fi1) between 2 and 70 days post amputation (dpa).

Two dimensions of regeneration rate were measured using the photographs of regenerating forelimbs, rate of differentiation and rate of growth (as in Sessions & Larson, ‘87). The degree of differentiation of the regenerating forelimb was measured as the external appearance, using the staging system of Iten and Bryant (‘73). This system includes 13 morphological stages. The rate of differentiation was calculated by dividing the stage of the limb in each photograph by the number of days post amputation (stage/dpa; see Sessions and Larson, ‘74). Outgrowth was measured on days 14, 23, and 70 post amputation, using the software Image J (1.42) from the amputation plane to the tip of the regenerating limb bud down the midpoint of the limb. These time points correspond with the formation of early limb buds (14 dpa), moving from palette to early digits (23 dpa), and the completion of outgrowth (70 dpa; Iten and Bryant, ‘73). The rate of growth was calculated by dividing the measurement of new tissue growth (mm) by the number of days post amputation (dpa) (rate of growth=mm/dpa).

Thermal Preference of Regenerating Newts

Twenty newts were housed in an enriched aquarium with dechlorinated water at about 23 º C for a minimum of one week acclimation upon arrival. Newts were then subdivided to one of five groups (four individuals per group) and each individual randomly designated one of two treatments (sham or regenerating) by coin toss for a total of 10 regenerating and 10 sham individuals. The removal of two animals from the study due to escape and illness (a tapeworm) lead to the later addition of a sixth group (n=2) containing one regenerating and one sham animal. Data from the removed animals were not included in this study. Animals within an individual group were housed in a rectangular plastic container with perforated plastic lid (see description above) one day prior to the initiation of behavioural experiments. Water temperature in these small tanks ranged from 20.1 to 22.8 º C throughout the experimental trials (June through July, 2009). Although all animals were fed 3 times per week, days of feeding were varied to ensure that newts were fed one day prior to testing in the thermal gradient to maintain consistent satiation. Limb amputation was performed as described above. Sham animals were anaesthetized and placed on ice as above but sustained no injury. An effort was made to begin behavioral experiments at the same time of day, with the majority of experiments starting between 09 00 and 10 00. The exception was day 1 post amputation for group 6, which started at 15 00 due to an equipment failure.

To test temperature preferences, a thermal gradient apparatus with plexiglass walls and a copper floor (27 by 54 cm) was constructed and sealed at the joints to prevent water leakage. The walls of the apparatus were notched to allow the insertion of 3 opaque plastic dividers, creating four individual lanes (6.75 by 54 cm). Each lane was wide enough to allow a newt to turn around and move without constraint. The apparatus was filled with 1.2 L dechlorinated water. This provided a depth of about 5 mm water, enough water to avoid newt desiccation while preventing the establishment of a vertical temperature gradient. Water was circulated underneath each end of the gradient apparatus through copper tubing. Cold water was pumped through the copper tubing underneath one end of the apparatus while hot water was pumped underneath the other. A range of temperatures from about 10 to 40 º C was selected from Berner and Bessay (2006). Average gradient temperatures ranged from 9.1 (± 0.03) to 39.0 º C (± 0.04) and preliminary trials with uninjured newts found animals staying at 27 º C, leaving a considerable temperature range for newts to potentially select warmer or cooler temperatures. The copper floor was covered with white contact paper (Con-Tact) and the paper was marked with a line every inch down the length of the apparatus. The temperature of the gradient in each lane was determined prior to every thermal preference trial with a Sable Systems thermocouple meter (TC-1000) and temperature was corrected with a linear equation. Since this species of newt is known to orient to the magnetic compass (Phillips, '86), the orientation of the thermal gradient was kept constant in order to avoid this potential confounding variable.

To determine the thermal preference of the newts, individuals from a group were randomly placed into the center of the gradient within one of the four lanes. Each individual oriented randomly towards either the hot or cold end of the gradient. A web camera (Microsoft LifeCam), positioned above the gradient captured time-lapse images using Flix 3.3 (Nimis) every 5 minutes. Newts were kept in the gradient for a total of 5 hours. The first hour was treated as an acclimation period, allowing the newts to investigate their enclosure. Data from the acclimation period were not included in statistical analyses. The majority of newts in the preliminary trials settled into one area of the thermal gradient within this time period. In total, the newts' initial thermal preferences were tested six times: once prior to anaesthetic and amputation and again at 1, 3, 7, 10, and 14 days post amputation (dpa). Sham individuals underwent anaesthetic and thermal preference trials at the same time as regenerating individuals in their group, but sustained no injury.

An additional experiment was designed to differentiate between activity in the in the thermal gradient (exploratory behavior) and thermal preference. The thermal gradient apparatus was modified so that the temperature across the apparatus was consistently 25 ^{o}C. All other variables were the same as in the above experiment. If regenerating newts preferred 25 ºC, I expected animals to move back and forth in the thermal apparatus throughout the time period, being uninhibited by their injuries. If regenerating newts were less active due to injury and subsequent regeneration, I expected these animals to explore the thermal apparatus during the one hour acclimation period and then randomly select a position in the apparatus to sit. The initial movements of 8 uninjured newts across the thermal apparatus were recorded at 5 minute intervals for a period of 5 hours as described above. As above, the first hour was considered acclimation time and data from this time period were not statistically analyzed. The 8 animals' right forelimbs were amputated mid radius-ulna, as above. Seven dpa, the regenerating newts' movements within the 25 ºC thermal apparatus were recorded at 5 minute intervals for a period of 5 hours, with one hour acclimation.

Thermal Imaging of Regenerating Limbs

Regenerating newts were placed individually in a 12.5 cm diameter plastic container, with 15 cm high walls which prevented newts from climbing out. Since newts are small ectotherms, and body temperature closely matches that of the environment, the floor of the container was covered with reflective aluminum Nashua duct tape (Berry Plastics) to create a thermal contrast between animals and the background surface, due to changes in the infrared emissivity between the animals and the aluminum. A strip of black electrical tape (emissivity similar to animal tissue) was placed on the bottom of the container as a thermal reference. The container was located within a temperature-controlled environmental chamber, consisting of an air tight cooler (Coleman) in which the temperature was controlled (24.6 º C ± 0.1 on average) using a water bath connected to an internally mounted heat exchanger/fan assembly. High humidity (86.7% ± 0.5 on average) was maintained internally by bubbling water with an air stone in order to reduce evaporative heat loss from newts' skin. Humidity and temperature were measured using a Type T environmental meter (TC-1000, Sable Systems). A thermal imaging camera (Micron 1394) was located at the top of the sealed chamber and a perforation was made through the lid in order for the lens to enter the chamber. Assumptions regarding emissivity and thermal image analysis followed routinely employed techniques in animal thermoregulation (Tattersall & Gerlach, 2005; Tattersall et al., 2009; Tatersall & Cadena, 2010).

Thermal imaging immediately followed the thermal preference trials on days 1, 7, and 14 post-amputation. All 10 regenerating newts were imaged at days 1 and 7, but only 8 newts were imaged for day 14 post amputation because of thermal camera availability. Excess water was removed from the newts' skin prior to placement in the chamber by placing animals briefly on dry paper towel. Thermal image data was collected every 10 seconds for 20 minutes immediately following the animal's placement in the chamber and analyzed using 'regions of interest' tools with Mikro Spec RT software (Mikron). When both forelimbs were in an image frame, a bent line was drawn down the center of each forelimb, avoiding refraction from the floor. Lines were drawn proximodistally on each arm to the regenerating plane so that both lines measured the same distance. The average temperature of the pixels that made up each line was recorded for each analyzed frame, and the mean regenerating and uninjured forelimb temperatures were compared.

Statistical Analyses

All statistical analyses were performed using SPSS Statistics 17.0, and resultant p values were compared to an α-value of 0.05. Values are given as mean ± standard error, unless otherwise specified. Rates of regeneration (differentiation and growth) and comparisons of thermal preference between treatments were analyzed using independent student's t-tests assuming unequal variance, two-tailed unless otherwise specified. Thermal preferences within treatments (regenerating and sham), were compared using repeated measures ANOVAs, individual means compared by least significant difference (LSD) post hoc test, and pairwise t-tests. Thermal imaging of regenerating and uninjured limbs was analyzed using pairwise t-tests. Body condition (weight and snout-vent length) between groups and between treatments was compared using one way ANOVA, LSD post hoc test and independent student’s t-tests.

Results

Effect of Temperature on Rate of Regeneration

It was expected that small increases in environmental temperature would result in increasing rates of forelimb regeneration, affecting both the rate of differentiation and rate of growth. The effects of temperature on differentiation were minimal in the first two weeks, when limbs were mostly undergoing wound healing (stage 1) and blastemal formation (stages 2 and 3; see table 2-1). Following this period, the effects of temperature on differentiation became increasingly distinct with the rate of differentiation increasing with increasing temperature. This trend continued until about day 30 when limbs at higher temperatures were nearing completion of differentiation (stages 10-13).

The mean rate for completion of differentiation (stage 13/dpa to reach stage 13) increased steadily with increasing temperature, with the highest rate for completion occurring at 29 ºC (Fig 2-1). Newts housed at 29 ºC finished differentiating nearly twice as fast as newts housed at 23 ºC (t_9, $p<0.001$) and 1.4 times as fast as newts housed at 25 ºC (t_{14}, $p<0.05$). Although animals housed at 29 ºC had a higher mean rate of completion of differentiation than 27 ºC, this difference in rate was not significant (t_{13}, p=0.15). If an animal did not reach stage 13 by 70 dpa, the rate of completion was recorded as the maximum stage reached by the end of the experiment divided by 70 dpa. Housing animals at 23 ºC seemed to delay differentiation, with only 20% of the newts reaching stage 13 by 70 dpa. Limb stages at 23 ºC ranged from 9-13 at 70 dpa. Animals housed at 23 ºC had a lower rate of completion of differentiation than all other groups (25 ºC: t_{13}, $p<0.05$, one-tailed; 27 ºC: t_9, $p<0.05$, one-tailed). At 25 ºC, 60% of the newts reached stage 13 by 70 dpa with stages ranging from 9-13. At 27 ºC, 63% of the newts reached stage 13 by 70 dpa with stages ranging from 7-13. Housing newts at 29 ºC maximized differentiation with 100% of newts reaching stage 13 by 70 dpa.

It should be noted that one of the newts housed at 29 ºC had abnormal digit regenerates, with only two digits forming on the regenerating hand by 70 dpa. Because these two digits were long and fully separated, matching the description of the exterior appearance of stage 13 digits by Iten and Bryant (‘73), this animal was scored as a stage 13. Two other animals, housed at 23 ºC and 25 ºC, also seemed to have abnormal digit regeneration with only three digits developing. Based on the length and separation of the digits at 70 dpa, these animals were recorded as stages 11 and 12 respectively. Abnormal digit regeneration is not uncommon, Stock and Bryant (‘81) found that one out of ten *N. viridescens* amputated through the mid-tarsal region had a reduction in digit number. Removal of the three animals with abnormal digit regenerates did not affect the significance of results (results not shown).

Rate of growth (length of total forelimb outgrowth from amputation plane/dpa) was also affected by environmental temperature, although more variably during early stages of regeneration (Fig. 2-2). Housing animals at 23 ºC seems to lead to stunted forelimb growth. These newts maintained the lowest rate of growth throughout the experiment. Rates of growth at 23 ºC were significantly lower than 27 ºC and 29 ºC at all three time points (27 ºC, day 14: t_{18}, $p<0.01$; day 23: t_{17}, $p<0.05$; day 70: t_{11}, $p<0.05$, 1-tailed; 29 ºC, day 14: t_{17}, $p<0.05$, day 23: t_{17}, $p<0.01$; day 70: t_{11}, $p<0.001$) and significantly lower than 25 ºC at 23 dpa (t_{18}, $p<0.05$) and 70 dpa (t_{13}, $p<0.01$). Newts housed at 23 ºC also had significantly less regenerated forelimb tissue than the other groups by 70 dpa (Fig. 2-3; 25 ºC: t_{13}, $p<0.01$; 27 ºC: t_{11}, $p<0.05$, 1-tailed; 29 ºC: t_{11}, $p<0.001$). Unlike the results of Schauble and Nentwig ('74), forelimb outgrowth did not reach its maximum at 25 ºC. Rather, animals housed at 29 ºC had the most new forelimb tissue by 70 dpa, nearly twice the amount of animals housed at 23 ºC, 1.3 times the amount of animals at 25 ºC (t_{16}, $p<0.05$), and 1.4 times the amount of animals at 27 ºC (t_{13}, $p<0.05$) as well as the highest recorded rate of growth. On day 23, the mean rate of growth for animals housed at 29 ºC was 2.8 times faster 23 ºC (t_{17}, $p<0.05$), 2.0 times faster than 25 ºC (t_{17}, $p<0.05$), and 1.7 times faster than 27 ºC (t_{16}, $p<0.05$). However, 29 ºC was not exclusively the ideal environmental temperature throughout the regeneration period. At 14 dpa, newts housed at 27 ºC had the maximum rate of growth, 2.7 times faster than animals at 23 ºC (t_{18}, $p<0.01$), and 2.0 times faster than 25 ºC (t_{18}, $p<0.05$). There was no significant difference between mean rate of growth at 27 ºC and 29 ºC (t_{17}, $p=0.16$).

During this experiment, 9 animals died, 5 from 23 ºC, 2 from 27 ºC, and 2 from 29 ºC. Body condition was examined as a potential contributing factor in animal deaths. There was no significant difference in animals' weight or snout-vent length between the four temperature groups (weight: $F_{3, 36}=1.070$, $p=0.375$; snout-vent length: $F_{3, 36}=1.439$, p=0.248), nor was there a difference in weight or snout-vent length between animals that lived and animals that died (weight: t_{38}, p=0.475; snout-vent length: t_{38}, p=0.405).

Thermal Preference of Regenerating Newts

It was expected that newts with regenerating forelimbs would select a warmer environmental temperature than uninjured (sham) animals. The initial temperature selections of both groups of animals prior to amputation were virtually identical (Fig. 2-4; t_{18}, p=0.994). Over the course of two weeks post amputation, regenerating newts consistently selected a mean environmental temperature of 25 ºC, with no significant changes in regenerating newts' temperature selection over time (mean range 24.3-25.2 ºC; $F_{5,\ 9}$=0.743, p=0.596) while sham animals' mean environmental temperature selection steadily decreased (mean range 21.7-24.0 ºC, $F_{5,\ 9}$=2.845, p<0.05). Regenerating newts selected an environmental temperature 2.6 ºC warmer than sham animals by 14 dpa (t_{18}, p<0.05, one-tailed), even though their selected temperature did not vary over the experimental time period. Over time, sham animals' mean temperature preference decreased linearly ($F_{1,9}$=7.949, p<0.05) with the temperature preference at 14 dpa 3.5 ºC lower than initial preference (pairwise t_9, p<0.05). Body condition did not differ between regenerating and sham animals (weight: t_{18}, p=0.981; snout-vent length: t_{18}, p=0.416).

An examination of animals' movements in the thermal gradient apparatus during the preference trials revealed that uninjured animals walked back and forth across the gradient more each time they were placed in the apparatus. Regenerating newts tended to explore the apparatus for the initial hour and then settle around a small temperature range. Uninjured newts tended to spend more time exploring the cooler end of the gradient. A visible aversion to high temperatures (above 30 ºC) was observed in both groups (Fig. 2-5). Often, newts sitting at the warm end of the gradient were observed curling their tail towards the cool end in what appeared to be an avoidance of extreme temperatures. Uninjured newts' increasing exploration of the temperature apparatus resulted in an increased coefficient of variation (CV) over the course of experimentation ($F_{5,9}$=2.441, p<0.05) with the CV at 14 dpa 2.3 times greater than the initial preference trial (Fig. 2-6; pairwise t_9, p<0.05). Regenerating newts' CV remained stable throughout the experiment ($F_{5,9}$=0.137, p=0.983).

Unlike the thermal gradient trials, regenerating newts moved back and forth across the 25 ºC thermal apparatus for the entire time period (Fig. 2-7). For both pre- and post-amputation trials, there was a visible edge effect, where animals showed a preference for the ends of their lanes. This effect was not seen in the thermal gradient trials; particularly, no animals were observed in the 39 ºC end of the gradient likely due to the high temperature. Regenerating animals moved frequently across the constant temperature apparatus and appeared uninhibited by their regenerating forelimbs. An analysis of CV between pre- and post-amputation trials revealed that regenerating newts had significantly more variation (pairwise t_7, p<0.05) suggesting that at 7 dpa, regenerating newts moved back and forth across the apparatus more than when animals were uninjured. The results of this experiment support the hypothesis that regenerating newts in the thermal gradient preferred 25 ºC and were not limited in their mobility by forelimb injury.

Thermal Imaging of the Regenerating Limbs

Regeneration significantly increased limb temperature on day 14 post amputation; regenerating forelimbs were 0.04 ºC warmer than uninjured forelimbs (pairwise t_7:

$p<0.05$, one-tailed). There was no difference between regenerating and uninjured limbs on 1 dpa (pairwise t_9: $p=0.296$) or 7 dpa (pairwise t_9: $p=0.798$) (Table 2-2).

Discussion

Changes in temperature as small as 2 ºC had a visible effect on both the rate of differentiation and the rate of growth of red-spotted newt regenerating forelimbs. Temperature's effects on the rate of regeneration mirrored other physiological functions in the red-spotted newt such as digestive rates and oxygen consumption which increase with increasing temperature (Jiang and Clauseen, '93; Pitkin, '77 respectively). Rate of courtship behavior and locomotor performance are also temperature dependant in urodeles (Denoël, '98, Denoël et al., 2005; and Else and Bennett, '87 respectively).

There are several possible explanations for the mortality rates of newts housed in diurnal growth chambers in addition to environmental temperature differences. One possibility was the use of chilling newts on ice for 20 minutes prior to photographing limbs. This was done in an effort to reduce animal movement, however there seemed to be a link between this procedure and animal deaths. Raffel et al. (2006) found a link between temperature variability and increased susceptibility of red-spotted newts to infection. Chilling newts was discontinued which reduced the death rate. A reduced temperature could have also made newts at 23 ºC more susceptible to infection resulting in increased death rate. A study on the effects of temperature on cutaneous wound healing in common garter snakes (*Thamnophis sirtalis*) found that snakes held at lower temperatures had a decreased rate of healing compared with snakes at higher temperatures. The wound areas in these animals remained open for a longer period of time, had an increased inflammatory area, and a prolonged inflammatory response (Smith et al., '88). Similarly, frogs can be cleared of chytrid infections by elevating body temperature (Woodhams et al., 2003). The overall effect of animal deaths remains unknown but the general pattern of results were consistent with previous temperature research on *N. viridescens* (Schauble and Nentwig, 1974) and fiddler crabs (Weis, 1976), in that rate of regeneration increased with increasing temperature.

Animals housed at 23 ºC consistently had the slowest rate of regeneration with the least regenerated tissue and slowest differentiation of any group by day 70 post amputation. However, much like the results of Schauble and Nentwig ('74), it is difficult to conclude a single optimal temperature for regeneration because rates changed over time and with type of measurement. Early in regeneration (14 dpa), animals at 27 ºC had maximum rate of growth but no discernible difference in stage of differentiation from any other group. The majority of animals from all temperature groups at 14 dpa were at stages 2 and 3. The maximum rate of growth measured in this experiment was achieved at day 23 post amputation by newts at 29 ºC. At this point in time, animals at 29 ºC had an extremely wide range of limb stages from 3-12. Yet the mean stage of this group (stage 9) was consistent with Iten and Bryant ('73). By 70 dpa, newts at 29 ºC had the most total new tissue and had all completed differentiation, but the overall rate for completion of differentiation was not significantly higher than 27 ºC. While these results cannot pinpoint an optimal thermal environment for enhancing regenerative research, they do draw attention to an important variable that is often not recorded in laboratory studies on regeneration. Housing newts in environmental temperatures that vary by only 2 ºC can significantly alter the rate of regeneration. Environmental temperature could become a confounding variable if not controlled for when using ectothermic model species.

In light of the effects of temperature on limb regeneration, given a choice of environmental temperatures, regenerating newts consistently selected 25 ºC during the first two weeks of regeneration. This temperature was the same as animals' thermal preference prior to amputation in this study, and nearly the same as the thermal preference (24.5 ±0.3) of newts acclimated to summer conditions in Berner and Puckett (2010). These results lead the author to question whether regenerating newts remained at 25 ºC due to temperature preference or were less active due to injured forelimbs. Newts' thermal preference while regenerating follows the same trend as lizards regenerating autotomized tails. Rock lizards (*Lacerta monticola*) and metallic skinks (*Niveoscincus metallicus*) do not alter thermal preference while regenerating (Martín and Salvador, '93; Chapple and Swain, 2004 respectively). Furthermore, rock lizards modify thermoregulatory behavior by lengthening duration of basking periods, lowering movement rates compared to tailed lizards while maintaining an identical body temperature (Martín and Salvador, '93). Regenerating newts in the thermal gradient were not less active due to their injuries. Newts were actually more active in the 25 ºC apparatus when they were regenerating forelimbs. This suggests that newts in the thermal gradient remained stationary to maintain a tighter regulation of their preferred body temperature. The high temperature sensitivity of the regeneration process emphasizes the importance of maintaining a narrow range of body temperatures.

At 14 dpa, newts selected a cooler temperature than that which would maximize rate of growth (27 ºC). This result did not support our hypothesis that newts would select an optimum temperature for regeneration. Rather, regenerating newts maintained a stable thermal preference, corresponding to a temperature that confers a moderate rate of regeneration. This result is not entirely surprising considering regenerating newts must maintain whole body physiological function. While optimal temperatures for respiration, digestion, locomotion, and immune system function are unknown, at least some of these daily physiological functions are likely optimum at the newts' preferred temperature. This is true for amphibian eggs, which are deposited at an environmental temperature optimal for growth and development (Hutchison and Dupre, '92), as well as mudpuppy (*Necturus maculosus*) swim velocity (Miller, '82; Hutchison and Hill, '76).

Similarly, Huey ('92) compared studies of the thermal optima of several physiological processes to the preferred temperature of two species of lizards, *Sceloporus occidentalis and Dipsosaurus doralis*. Preferred temperature corresponded to a temperature range that supported high performance of physiological processes, despite differences in the absolute optimum temperature of each process. Furthermore, variation in temperature has been linked to increased susceptibility to infection in red-spotted newts (Raffel et al., 2006). Our results suggest that an optimal strategy for regenerating newts may be to maintain a stable body temperature rather than increase body temperature to maximize rate of regeneration. Unlike regenerating animals, uninjured newts did not remain at 25 ºC over the two weeks of trials in the thermal gradient. These animals walked back and forth across the gradient and therefore spent more time in cooler environmental temperatures. Since extreme warm temperatures (>30 ºC) were avoided, this allowed the mean selected temperature to drop. Sham animals' exploratory behavior was likely due to habituation to the thermal gradient over time. Uninjured newts continually attempted to escape the thermal gradient while regenerating newts opted to thermoregulate. However, when placed in a constant 25 ºC apparatus, regenerating newts tried to escape the apparatus as much, if not more than when they were uninjured. From this, we conclude that accurate thermoregulation around a preferred temperature may be more important to regenerating individuals.

Interestingly, at day 14 post amputation, regenerating forelimbs were warmer than uninjured forelimbs. Although the measured difference in temperature was small (0.04 ºC), this increase in temperature is likely biologically significant. First, the thermal camera non-invasively measured radiant heat from animals' surfaces. A subcutaneous probe may have revealed larger differences in limb temperature. Second, Berner and Puckett (2010) demonstrated that some newt metabolic enzymes have Q_{10}s between 1 and 2, demonstrating that rate of reaction will increase with increasing temperature. Subcutaneous hyperthermia has been shown to increase wound healing and decrease infection in mammals (Ikeda et al., '98; Jönsson et al., '91; Jönsson et al., '81) and behavioral fevers are a host defense mechanism for fighting infections in ectotherms and mammals (Kluger, '79; Woodham et al., 2003). However, to our knowledge, injury site-specific hyperthermia has not been observed in ectotherms. Perhaps this localized temperature increase allows newts to enhance the rate of regeneration while maintaining stable preferred whole body temperature.

Laboratory measurements of limb regeneration in newts have informed much about the importance of temperature in healing and tissue regrowth. This study contributes to this area of research by demonstrating that newts behaviorally thermoregulate to maintain a stable preferred temperature. Yet it is unclear whether, like rock lizards, red-spotted newts would alter movement and microhabitat selection in the wild to maintain preferred body temperature while regenerating. Furthermore, since thermal preference in newts is known to be lower under winter acclimation conditions which favor changes in underlying biochemistry (as in Berner and Puckett, 2010), it is possible that limb regeneration in winter-acclimated newts is associated with changes in thermal optima. Finally, the results of this section beg the question of whether intraspecific differences in the thermal preference among urodele species could account for at least some of the variation in regenerative ability? Future studies could benefit from examining the importance of temperature, the potential for thermal optima in regeneration, and the thermal preferences of animals during regeneration.

Table 2-1. Mean stage of differentiation (± standard error) by days post amputation (dpa) for regenerating red-spotted newts housed in four thermal environments: 23, 25, 27, and 29 °C.

Temp (°C)	Days post amputation (dpa)									
	7	14	19	23	26	28	33	44	50	70
23	2.1 (± 0.3)	2.6 (± 0.2)	3.0 (± 0.2)	3.3 (± 0.2)	3.8 (± 0.3)	4.2 (± 0.4)	5.5 (± 0.4)	8.5 (± 0.8)	9.17 (± 0.9)	10.4 (± 0.8)
25	2.3 (± 0.3)	2.7 (± 0.2)	3.8 (± 0.3)	5.5 (± 0.8)	7.8 (± 0.9)	9.0 (± 0.8)	10.0 (± 0.6)	11.3 (± 0.5)	11.5 (± 0.4)	12.3 (± 0.4)
27	2.0 (± 0.3)	3.2 (± 0.3)	4.3 (± 0.5)	7.3 (± 0.8)	8.3 (± 0.8)	9.1 (± 0.8)	10.0 (± 0.8)	10.9 (± 0.9)	11.8 (± 0.7)	12.0 (± 0.7)
29	2.5 (± 0.2)	3.2 (± 0.2)	5.6 (± 0.8)	8.6 (± 1.1)	10.1 (± 0.7)	11.4 (± 0.4)	11.6 (± 0.3)	12.3 (± 0.3)	12.8 (± 0.2)	13.0 (± 0.0)

Table 2-2. Mean temperature (± standard error) of uninjured and regenerating forelimbs, measured at 1, 7, and 14 days post amputation (dpa).

Days Post Amputation	Mean Uninjured Limb Temperature (° C)	Mean Regenerating Limb Temperature (° C)
1	23.57 (±0.13)	23.53 (±0.13)
7	23.15 (±0.13)	23.14 (±0.12)
14	23.06 (±0.21)	23.10 (±0.21)

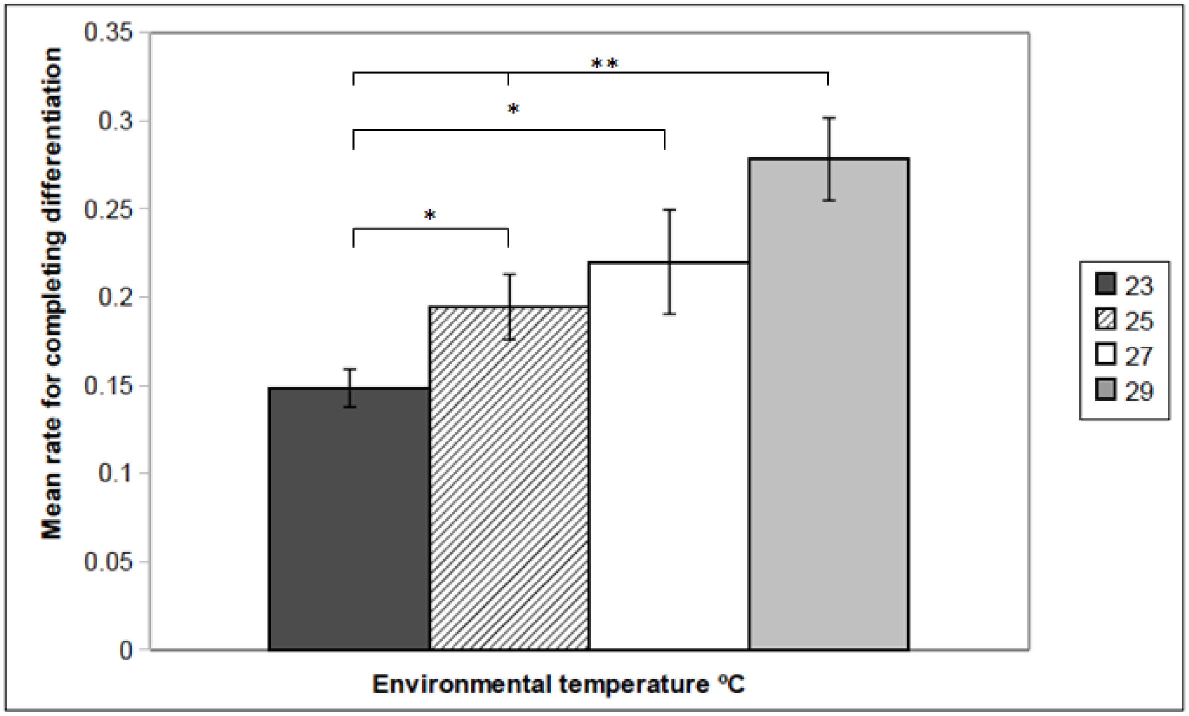

Figure 2-1. Mean rate for completion of forelimb differentiation (stage 13/number of days post amputation) of red-spotted newts housed in four thermal environments: 23 (n=5), 25 (n=10), 27 (n=8), and 29 °C (n=8). Standard error bars shown. Significant differences between 29 °C and 25 °C as well as 29 °C and 23 °C represented by (**): Two-tailed, independent T-tests assuming unequal variance (P<0.05). Significant differences between 27°C and 23 °C as well as 25 °C and 23 °C represented by (*): One-tailed, independent T-test assuming unequal variance (P<0.05). There were no significant differences between 25 °C and 27 °C (P=0.412) and 27 °C and 29 °C (P=0.083).

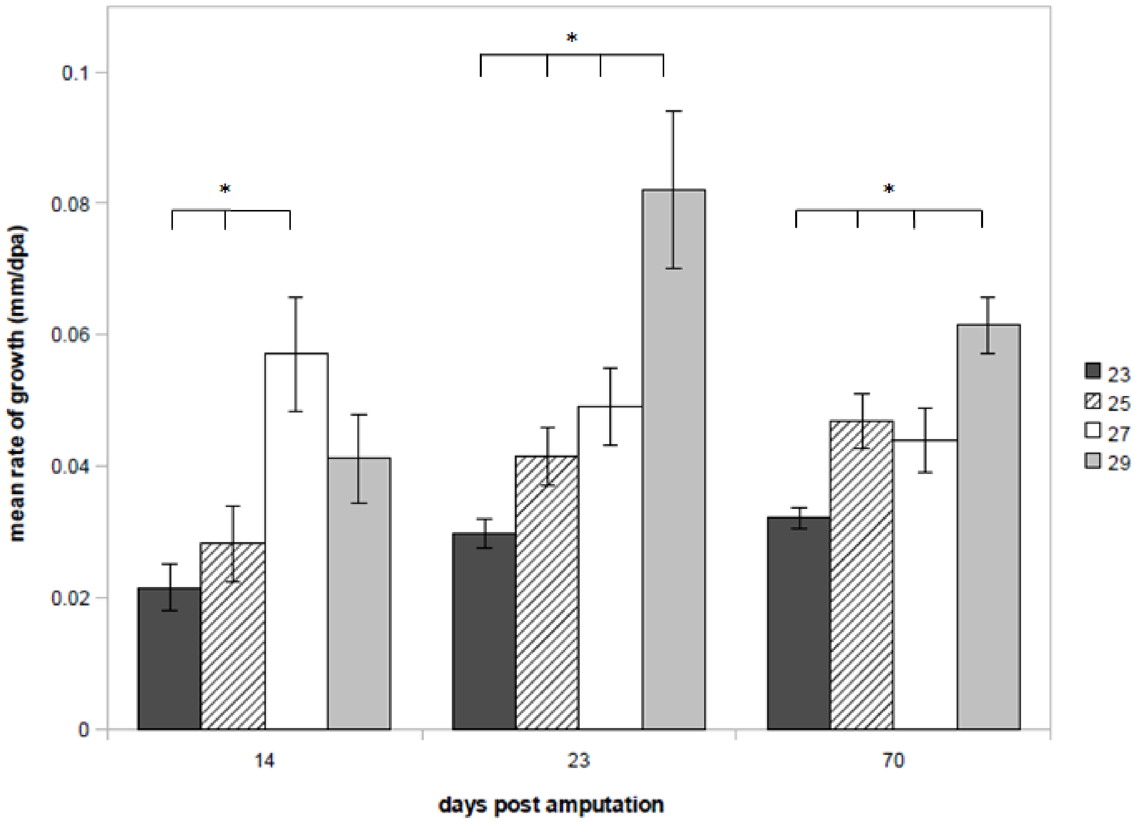

Figure 2-2. Mean rate of growth (total regenerated tissue from amputation plane/number of days post amputation) for regenerating forelimbs of red-spotted newts, housed at four environmental temperatures: 23, 25, 27, and 29 °C . Standard error bars shown. On day 14 post amputation, newts housed at 27 °C had a significantly higher rate of growth (represented by *) than 23 °C and 25 °C: Two-tailed, independent T-tests assuming unequal variance (P<0.05). There was no significant difference between 27 and 29 °C (P=0.093). On day 23 post amputation, newts housed at 29 °C had a significantly higher rate of growth (represented by *) than 23 °C, 25 °C, and 27 °C: Two-tailed, independent T-tests assuming unequal variance (P<0.05). On day 70 post amputation, newts housed at 29 °C had a significantly higher rate of growth (represented by *) than 23 °C, 25 °C, and 27 °C: Two-tailed, independent T-tests assuming unequal variance (P<0.05).

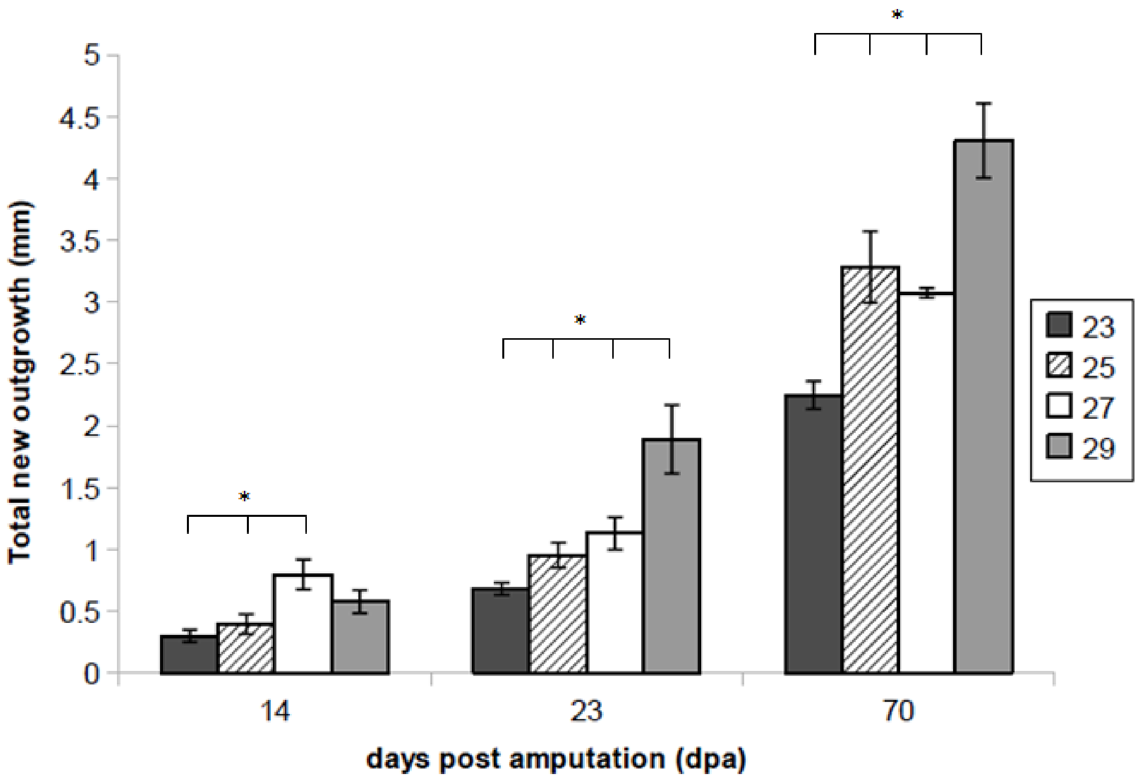

Figure 2-3. Mean outgrowth from the amputation plane of regenerating forelimbs of red-spotted newts, housed at four environmental temperatures: 23, 25, 27, and 29 °C. Standard error bars shown. On day 14 post amputation, newts housed at 27 °C had significantly more regenerated tissue (represented by *) than 23 °C and 25 °C: Two-tailed, independent T-tests assuming unequal variance ($P<0.05$). There was no significant difference between 27 and 29 °C ($P=0.164$).On day 23 post amputation, newts housed at 29 °C had significantly more regenerated tissue (represented by *) than 23 °C, 25 °C, and 27 °C: Two-tailed, independent T-tests assuming unequal variance ($P<0.05$). On day 70 post amputation, newts housed at 29 °C had significantly more regenerated tissue (represented by *) than 23 °C, 25 °C, and 27 °C: Two-tailed, independent T-tests assuming unequal variance ($P<0.05$).

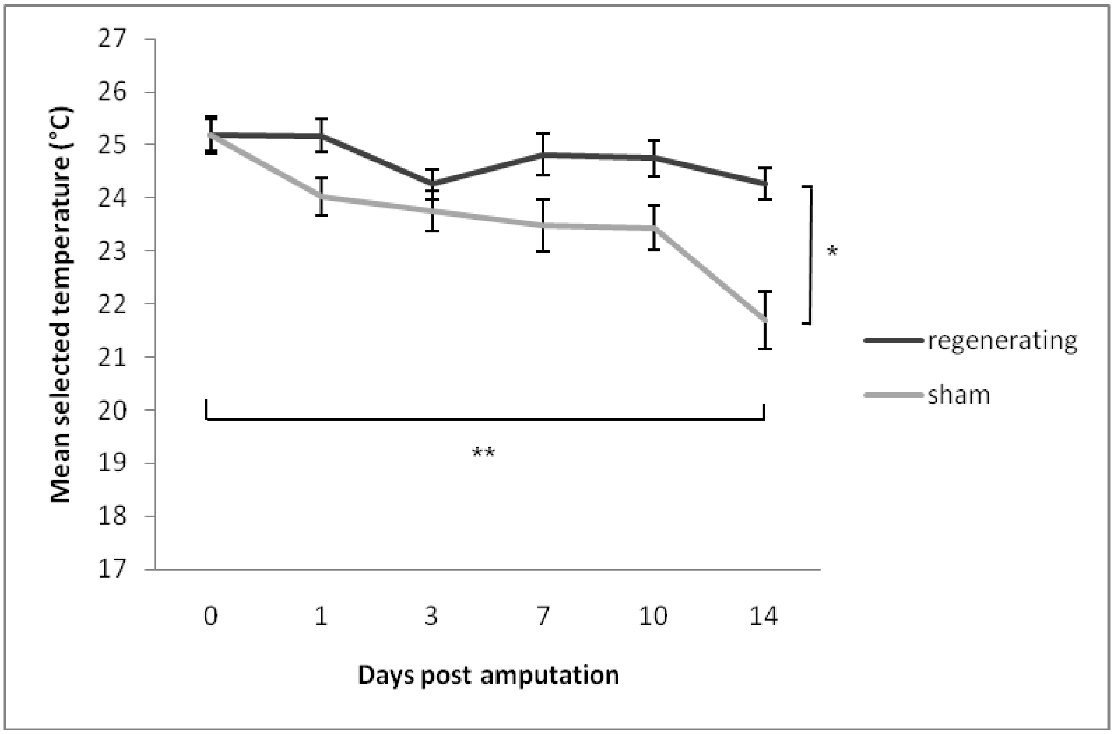

Figure 2-4. Mean selected temperature (°C) of regenerating (n=10) and sham (n=10) newts in a thermal gradient apparatus at the following time points: pre-amputation (0), days 1, 3, 7, 10, and 14 post-amputation. Standard error bars shown. On day 14 post amputation, regenerating newts selected a significantly warmer temperature (represented by *) than sham animals: One-tailed, independent T-test assuming unequal variance ($P<0.05$). Sham animals' temperature selection decreased significantly over time (represented by **): Repeated measures ANOVA, least significant difference post hoc ($F_{5,9}=2.845$, $P<0.05$).

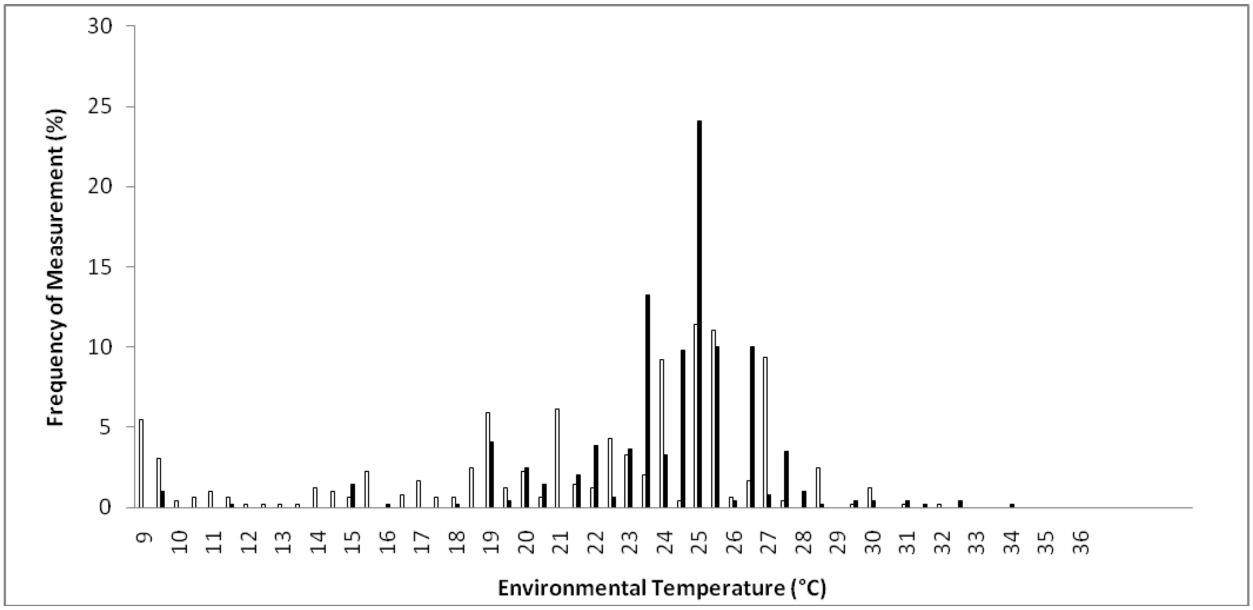

Figure 2-5. Frequency distribution (%) of environmental temperature selection by regenerating (black, n=10) and sham newts (white, n=10) at 14 days post amputation. Bars represent the percentage of times a newt from a particular treatment (forelimb amputation vs. sham) selected an environmental temperature within a 0.5 °C span. For example, the bars at 25 represent data including 25.0-25.4 °C. All individual measurements are included for a four hr. preference trial following a one hr. acclimation period.

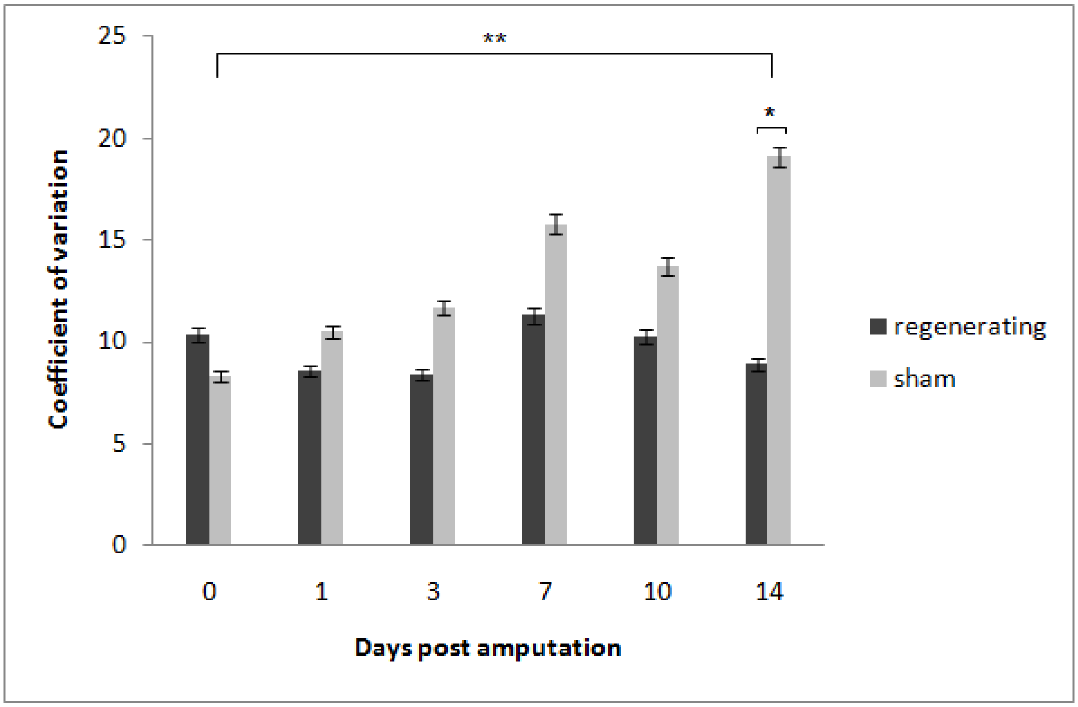

Figure 2-6. Mean coefficient of variation (CV) of regenerating (n=10) and sham (n=10) newts during 4 hour thermal preference trials in a thermal gradient at the following time points: pre-amputation (0), days 1, 3, 7, 10, and 14 post-amputation. Standard error bars shown. Sham animals had increasing CV over time(represented by **): Repeated measures ANOVA, least significant difference post hoc ($F_{5,9}$=2.441, p<0.05).On day 14 post amputation, sham animals also had significantly higher CV (represented by *)than regenerating newts: One-tailed independent T-test assuming unequal variance (P<0.05).

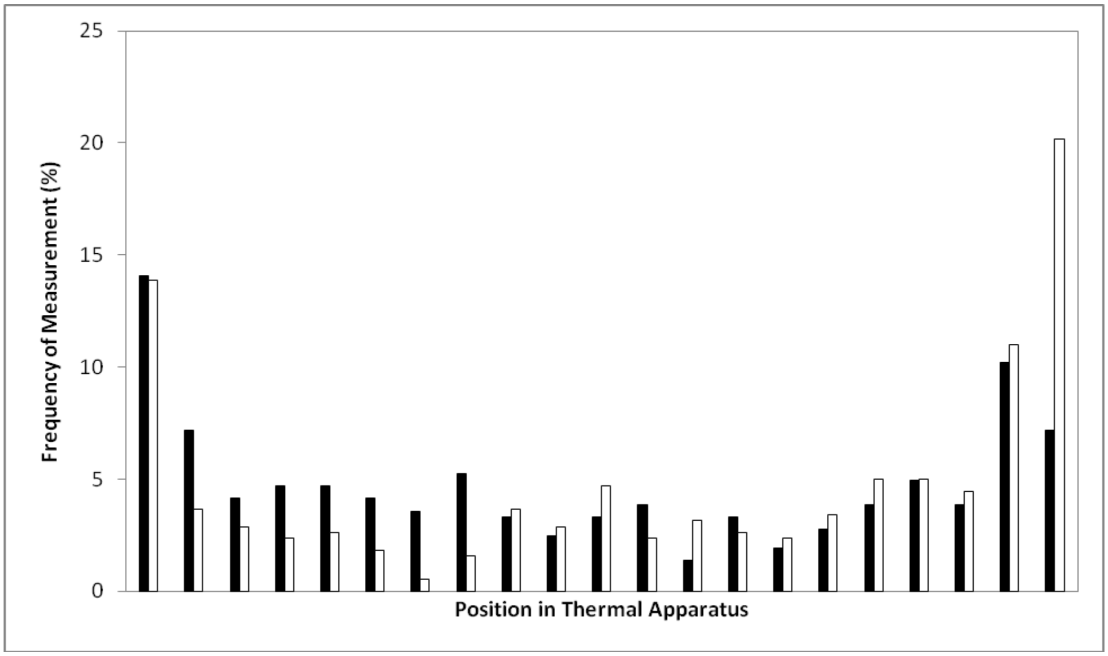

Figure 2-7. Frequency distribution (%) of newts' position along a 25 °C thermal apparatus. The positions along the 25 °C thermal apparatus correspond to positions between 9 °C (left side of the graph) and 39 °C (right side of the graph) from the thermal gradient apparatus (as in Fig. 5 above). Measurements for newts (n=8) were recorded pre- (white) and 7 days post amputation (black). Bars represent the percentage of times a newt from a particular trial (pre- vs. post-amputation) was measured at a position in the apparatus. Positions in the apparatus were 2.5 cm apart. All individual measurements are included for a four hr. trial following a one hr. acclimation period.

CHAPTER 3
LITERATURE REVIEW

Nonformal Education

While the term nonformal education is relatively new, introduced by Coombs in 1968; “the practice is as old as education itself” (p. 12, Thompson, ‘95). Children in particular learned by participation in activities such as farming, fishing, weaving, and carving, in preparation for adult social and political responsibilities (Thompson, ‘95). Formal interest in nonformal education was sparked by policymakers and development analysts as a means of tackling social problems such as rural poverty, healthcare, and famine (Coombs, ‘76). Valued for its flexibility and adaptability for meeting diverse learning needs, Coombs (‘76) describes nonformal education as “a convenient label covering a bewildering assortment of organized educational activities outside the formal system that are intended to serve identifiable learning needs of particular subgroups in any given population-be they children, youths, or adults; males or females; farmers, merchants or craftsmen; affluent or poor families.” p. 282.

With a growing concern for secondary students’ college and career readiness (Greene and Forster, 2003; Millieken, 2007; ACT, 2009; Khan et al., 2009), nonformal education poses a promising venue for career development (Eccles and Templeton, 2002; Johnston et al., 2004; Durlak and Weissburg, 2007). Nonformal education is generally hands-on and experiential (learning through direct experiences). This approach to education can be especially beneficial for enhancing both cognitive and social learning and achievement in youth by providing opportunities for success in addition to family and school. Typical North American nonformal education programs for youth include 4-H programs, Girl Guides, Boy Scouts, and cultural and religious youth groups. Nonformal education can also ease the transition into adulthood by offering programs that help adolescents gain exposure to employment opportunities and other adult roles such as leadership and community service (Dubas and Snider, ‘93).

Nonformal Curriculum Development

“Planning is by its very nature an act of ‘prediction’;” p. 4, Farrell, 2008. In the 1970s, the planning and development of nonformal education programs was “hit-or-miss”, carried out independently by the nonformal programs (Coombs, ‘76). There were no guidelines or standards to follow to guide the development of nonformal programs as there are today. Yet, regardless of how recently or long-ago programs were implemented, successful nonformal programs seem to share three key features: (1) objectives tied to learners’ needs, (2) effective resource management and sustainable budgets, and (3) evaluations for continual reflection and revisions (Coombs, ‘76; Carlson and Maxa, ‘97; North American Association for Environmental Education (NAAEE), 2004; Jacobson et al., 2006).

(1) If a nonformal education program is to be successful it must meet its target audience(s)’ or learners’ needs. Participation in nonformal education is voluntary, there is no compulsory attendance as in formal education (Coombs, 1976). If the needs of learners are not met a program will fail because participants will not attend, fail to sign-up, or drop-out depending on the context. Consideration of the target audience(s) needs include: learners’ motivations and/or felt needs, age, gender, and cultural perspectives; knowledge and skill levels; learning styles; kind and duration of program most appropriate to meet needs; and inclusiveness in culture and accessibility (complies with the Americans with Disabilities Act) (NAAEE, 2004; Morrison et al., 2007). (2) Nonformal education programs must, in general, procure their own funding. The

dependence on donations and grants from external funding agencies means that nonformal education programs, especially relatively young programs, must be able to develop programs with very frugal budgets. These programs must also be adaptable if one or more sources of funding fall through. But as Coombs (‘76) describes, nonformal programs are also at a fiscal advantage because of their “ability to use borrowed facilities or to get along with no facilities at all (the shade of a tree will do)...[and] to draw on competent people on a part-time basis, either paid or voluntary.” p. 289. Community partnerships can also be formed to share resources (NAAEE, 2004). (3) Evaluations are important for reporting progress to funding agencies, but they are also an essential element of curriculum design and directly tied to effective resource management. Evaluations answer the questions: “Are learners’ needs being met?” and “To what extent is learning being achieved?” Answers to these questions help keep programs learner-centered as well as efficient and effective. Evaluation results are used to carefully determine program strengths as well as required revisions to curriculum design. There are three types of evaluations which assess a program at different stages of curriculum development. Formative evaluations are generally implemented during curriculum development. These evaluations are meant to identify weaknesses in the program curriculum before full-scale implementation. As Morrison et al. (2007) describe, “Formative evaluation is quality control of the developmental process” p. 238. Summative evaluations are carried out at the end of a program in order to measure the effectiveness of a program and the degree to which objectives are obtained. Confirmative evaluations measure the long-term outcomes of a program and whether learner’s needs are being met over time. For example, learners’ knowledge may have improved at the end of a five day course, but three months later learners may not remember what they have learned.

Given the requirements for successful nonformal education programs, Morrision et al.'s (2007) Instructional Design (ID) method is ideal for nonformal curriculum development. Table 3-1 presents the components of this design process. Although there are steps to the ID process, the design does not follow a linear trajectory. More so, there are cycles which suggest curricular revisions (Fig 3-1). The aim of ID is to develop the most effective design for meeting learners' needs, given known constraints such as resources, cost, and time.

Nonformal Environmental Education

Ecosystem management is a social as well as a biological challenge. Without public support, researchers will fail to achieve conservation goals (Jacobson et al., 2006). Environmental education (EE) focuses on topics such as ecosystems, natural resources, environmental problems, conservation, and restoration. Environmental Education is taught both formally and nonformally. Formal EE includes classroom curriculum while nonformal EE takes place in a wide range of settings including conservation areas, summer camps, zoos, aquariums, green spaces, and backyards. The ultimate goal for EE is "pro-environmental behavior", or a more comprehensive term, environmental action (Chan, '96; Jensen, 2002 respectively). Emmons ('97) defines environmental action as "a deliberate strategy that involves decisions, planning, implementation, and reflection . . . to achieve a specific positive environmental outcome" p. 35. However, people are not born as environmentally active citizens. Environmental educators cannot simply "sell" the idea of environmental action and expect people to change their behavior overnight. Hungerford and Volk ('90) hypothesized that there is a linear progression to environmental action and research has focused on necessary prerequisites; highlighting the specific precursor environmental attitudes, which is made up of three components: knowledge of the environment (cognitive), affect (emotional concern for the environment), and behavioral intention (Kaiser et al., ‘99). Additionally, qualitative studies examining environmentally active individuals have found that significant life experiences are catalysts which fuel the transition from environmental appreciation and awareness into action (Chawla, ‘98; Chawala, ‘99; Arnold et al., 2009). Some of the most common significant life experiences include: time spent in nature, parents, role models, education, and participation in environmental organizations. UNESCO (‘78) identified goals of EE programs which, in effect, build stepwise opportunities for the public to transition to environmental action. Jacobson et al. (p. 9, 2006) describe these goals from UNESCO (‘78) as “opportunities to gain:

- Awareness-to acquire an awareness of and sensitivity to the environment and its associated problems.
- Knowledge- to gain a variety of experiences in and acquire a basic understanding of the environment and its associated problems.
- Attitudes- to acquire a set of values and feelings of concern for the environment and the motivation for actively participating in environmental improvement and protection.
- Skills- to acquire the skills for identifying and solving environmental problems .
- Participation- to encourage citizens to use their knowledge to become actively involved at all levels in working toward resolution of environmental problems.”

Educational outreach is a form of nonformal EE. It is intended to take “scientific information out of the ivory tower and onto the streets” by having scientists lead seminars, discussions, workshops, etc. with public audiences (p.4, Brewer, 2002). This interaction not only allows community members to learn about science, it allows scientists to learn the local public's preconceptions, knowledge, and attitudes towards the habitats scientists study; which is in effect an assessment of the target audience. Brewer (2002) describes five elements of successful educational outreach programs. The first is that the program should be experiential and inquiry based, allowing the participants to be stakeholders and take ownership over elements such as asking questions, experimental design, and interpreting results. The second is that collaboration with teachers is essential for supporting students throughout the outreach and determining the extent of student involvement. The third is a foundation in education, to ensure learners' needs are met. This foundation can be achieved through formal training or via collaboration with a colleague in science education. The fourth is proper training of participants and the fifth is program assessment. Brewer explains that program assessment is "particularly essential in the early stages of a program when curricula and approaches are being implemented for the first time" (p. 5, 2002). Thus, the requirements for successful nonformal EE program development, like the broader field of nonformal education, align well with Morrison et al.'s (2007) ID method. The use of needs assessments, evaluation instruments, and learning theory, to name a few elements, appear universally essential for effective nonformal curricular development and implementation.

Table 3-1. Components of instructional design, based on Morrison, Ross, and Kemp (2007)

Component	Description
Needs Assessment	Identify need for instruction (what is the problem?) Is the solution to the problem non-instructional? e.g. is poor productivity related to ergonomics, not training?
Learners and Context	Characteristics of target audience Learning styles, personal, social, and cultural characteristics Instructional environment (classroom, office, outdoors, etc)
Task Analysis	What learners need to know (knowledge) / be able to do (procedures) to achieve the goal/solve the problem
Objectives	Specific, measurable, timely What learners need to master Function of objectives: Design appropriate learner-centered instruction Framework for evaluating student learning Guide the learner
Instructional Strategies	Presenting information in ways that help learner integrate new information with ideas they already understand e.g. analogies, descriptions, simulations, demonstration, model, overt practice, mental rehearsal
Evaluation	Assess learner's mastery of objectives Identify elements of design that require revision

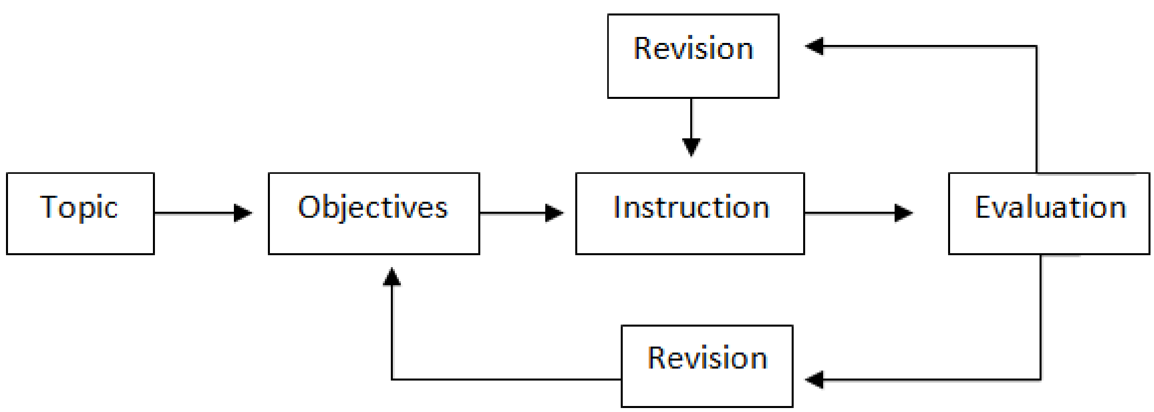

Figure 3-1. A typical instructional design model. From Morrison, Ross, and Kemp, p. 21 (2007).

CHAPTER 4
YOUTH-LED REPTILE OUTREACH: A NEW MODEL FOR COMMUNITY ENVIRONMENTAL EDUCATION

Introduction

Many people, young and old, believe snakes are slimy, deadly creatures, viewing reptiles with fear or disgust because of a lack of education. Young & Wild was a new after-school program in the Niagara region, Ontario, Canada, which trained volunteer secondary students to present hands-on reptile educational outreach to audiences using live snakes and turtles. Training and outreach presentations were provided free of charge to promote equal accessibility. There were two parts to the format of the community presentations. First, student presenters held native snakes and turtles while describing their anatomy, ecology, and conservation concerns. This was followed by a hands-on session in which audience participants had the supervised opportunity touch and hold multiple snake species. The aims of these nonformal environmental education experiences were to (1) focus on human behaviors that directly or indirectly threaten the survival of Ontario’s reptile species, and (2) to facilitate people to change their behavior and become more conservation oriented (Peters and Matarasso, 2005).

The Instructional Design (ID) method (Morrison et al., 2007) was used as a framework in the creation and implementation of both the outreach presentations and the training program for secondary student outreach presenters. J. Hathaway served as the primary subject matter expert (SME) for the ID process because of his 15 years of experience training and working alongside youth and adult educational outreach presenters for Sciensational Sssnakes!!, a company which has been delivering hands-on reptile and amphibian educational outreach across Canada since 1994. Additionally, stakeholders from community partners, funding agencies, and the University of Florida, as well as SMEs from a local environmental stewardship (Land Care Niagara) and a nonformal environmental education centre (Safari Niagara) were consulted for program development.

In this article, I focus on describing in detail the framework for the design of outreach presentations and the training program so that this design can be used as a model for future nonformal environmental education (EE) programs. Included are elements of the training program's information session, presenter handbook, group practice sessions, and presenter evaluations. The initial design was developed as an after-school training program for secondary students, with in-school presentations at local elementary schools. However, several logistical difficulties dictated the modification to after-school community presentations and led the authors to consider an alternative learning environment that may be better suited to this training program. Through a review of the program's challenges and revisions based on formative and summative evaluations, I` consider how these elements could be incorporated into an environmentally oriented week-long camp.

1. Reptile Educational Outreach

Need: Why is it Important to Have Reptile Educational Outreach?

The worldwide future of reptiles is becoming increasingly uncertain (Gibbons et al., 2000). In Canada, 41 out of 48 reptile species are listed as species at risk, with two species that lack sufficient data for designation (COSEWIC, 2010). In Ontario where this program was initiated, over half of all snake species and seven out of eight turtle species are species at risk (Ministry of Natural Resources, 2009). While the causes of population declines are complex, many factors are directly or indirectly related to humans including habitat loss and degradation (Gibbons et al., 2000), road mortality

(Bonnet et al., ’99; Gibbs and Shriver, 2002; Steen et al., 2006; Row et al., 2007), intentional killing (Wier, ’92; Ashley et al., 2007), and commercial harvest (Gibbon et al., 2000). Many Ontario reptile species are cryptic or nocturnal and are unknown or unappreciated by landowners. Without an awareness of the importance of these species in their ecosystems, Niagara community members will passively accept the decline or loss of local populations rather than taking an active role in conservation.

Learners: Target Audience for Educational Outreach

It is difficult to promote public support of reptile conservation and restoration in Ontario partly because the species found here are not charismatic megafauna (Barney et al., 2005; Leader-Williams and Dublin, 2000). Although people report that they care about the environment, public knowledge about conservation is minimal. Concern for wildlife is largely confined to attractive and emotionally appealing species such as dolphins and giant pandas (Jacobson et al., 2006). Snakes are often perceived with negative attitudes of fear and disgust. Driscoll (’95) found that people's attitudes of rattlesnakes are clustered with rats and tarantulas in that these animals were perceived as very unlovable and dangerous. From personal experience, exposure to completely harmless snake species has caused people to cry, run away, and even faint in fear. Similarly, Mantil (’93) describes teachers touring the Toronto Zoo who invariably make negative comments about snakes or express phobias. The cause of these intense aversions is not clear, but it is suggested that negative experiences in pre-adolescence lead to the development of phobias (Wilson, 2007). It is because of this age-dependant sensitivity to developing negative attitudes towards snakes that I selected elementary school-aged children as our target audience participants. Through nonformal education and hands-on interaction with snakes, I hoped to facilitate positive changes in attitudes towards snakes and conservation-oriented behaviors (UNESCO, ’78).

Learning Goals and Objectives of Target Audience for Educational Outreach

The learning goal for audience participants was to develop an appreciation for reptiles' place in the ecosystem. Positive attitudes towards the environment have been established as precursors to ecological behavior (Kaiser et al., ’99), which is defined as “actions which contribute towards environmental preservation and/or conservation” (Axelrod and Lehman, ’93, p. 153). The task analysis identified actions that an adult who appreciated reptiles’ place in the ecosystem would take: e.g supporting conservation and restoration projects, not killing reptiles out of fear or for sport, and helping turtles cross the road. Learning objectives were developed to first focus on a shift towards positive attitudes and second give learners the knowledge to act as conservation-oriented adults (Fig 4-1).

Presentation Strategies

Outreach presentations had two sections: in the first half, student presenters held live snakes and turtles while delivering curricular content about Ontario reptiles. This curricular content contained instructional messages which directly related to learning objectives (see Table 4-1). Each reptile species was selected as a learning tool so that instructional messages became meaningful and memorable by “bringing reality into the room” (Sherwood, ’89; Heath and Heath, 2008 respectively). In particular, the Milk snake was selected because its blotchy patterning and “rattling” defense behavior (shaking its tail against other objects to produce a rattle sound without a rattle on the end of the tail) result in the Milk snake often being mistaken for the threatened Massasauga rattlesnake. The Milk snake provided a fluid opening for dispelling myths about rattlesnakes and discussing conservation concerns for species at risk. Additional consideration of species selection included animals that are found in the region, ease of husbandry and transportation, and animal temperament (Barber, 2008). Student presenters modeled handling of snakes and turtles not only to demonstrate proper handling techniques for the hands-on portion of the presentation, but also as a desensitization strategy to improve audience attitudes towards snakes. In theory, modeling neutral interactions with a snake may cause fearful audience members to re-examine preconceptions that have not been supported by direct observation. For example, a fearful viewer may be surprised when a snake is not trying to bite, attack, or constrict a presenter but rather lazily resting on a hand. The conflict between observation and preconception may lead to a positive shift in attitudes. Modeling neutral interactions with animals without adverse consequences has previously been shown to eliminate avoidance behavior in children fearful of dogs. Moreover, live demonstrations appeared to be more effective than watching a film (Bandura and Menlove, ’68).

A question and answer period and followed students’ verbal presentations. Audience members were encouraged to ask questions about reptiles and answers were provided by the SME. An explanation of the rules for handling snakes followed (Table 4-2). Then, in the second section of the presentation, audience participants voluntarily touched and held multiple snake species with instructors and student presenters’ support and supervision. Gentle coaxing was attempted for nervous audience participants- either a presenter or often a peer would encourage touching, “just the tip of the tail”. Audience members were pleasantly surprised that the snake did not feel cold and slimy as they had expected; the snakes felt smooth like a fingernail. This initial contact often progressed to holding the tail of the snake and then the entire snake within minutes, which made children and adults alike beam as they proclaimed, “I'm holding a snake!”. This progression was completely voluntary. No audience member was ever pushed or forced to touch or hold a snake. All snakes used for presentations were provided by Sciensational Sssnakes!! and were born and raised in captivity. The number and type of snakes used in the hands-on sessions depended on appropriate audience behavior. The risk of injury to the animals is much greater than the risk to audience members if rules are not followed at all times. We began with thicker bodied, able climbing species (Corn snakes and Black Rat snakes) because they are less likely to sustain injury from being inappropriately handled (squeezing) or falling to the ground. The audience was given the incentive that proper handling and demeanor (calm and composed, no horseplay) would result in more snakes being brought out during hands-on sessions. Only snakes were used in the hands-on section because of the risk of Salmonella transmission from aquatic turtles.

Outreach presentations were developed after Morgan and Gramann (’89) in that multiple teaching strategies (informational messages, modeling, and direct contact) were used in an effort to maximize positive changes in knowledge and attitudes (Fig 4-1). Direct contact was used quite extensively in comparison with Morgan and Gramann; not only were audience participants encouraged to touch a snake, in addition they had the opportunity to touch and hold multiple snake species. Due to the requirements of mobility of presentation material, mere exposure was not included. Display tanks were not ideal for hour-long presentations which had to be moved to new locations frequently.

However, mere exposure alone has not been shown to increase students' positive attitudes towards snakes (Morgan and Gramann, '89).

2. Secondary Student Training Program

Need for Involving Secondary Students in EE

It is important to actively involve secondary students in environmental education (EE). Adults' ethical appreciation for nature is formed during teenage years (Kellert, '85). Particularly, teenagers' environmental sensitivities, actions, and leadership roles develop in association with significant life experiences (e.g. time spent in nature, role models, peers, and environmentally themed youth groups) throughout childhood and adolescence (Sivek, 2002; Arnold et al., 2009). Arnold et al. (2009) interviewed youth leaders in environmental action. Environmental action was defined as "a deliberate strategy that involves decisions, planning, implementation, and reflection . . . to achieve a specific positive environmental outcome" (p. 35, Emmons, '97). A young environmental leader was defined as an individual between the ages of 16 and 19 years who met four criteria: a positive attitude toward the environment, positive environmental behavior, initiative or leadership activity, and involvement in multiple spheres of action (Tanner, '98). The authors found that four out of 12 youth leaders described the transformation from interest and appreciation into environmental action occurring through school, but outside of conventional classroom learning. Early adolescence was the most frequent timing of transformational experiences that catalyzed transition into action. Furthermore, the youth experience in science (YES) program, in which teens taught science to five to nine year olds in an after-school setting has demonstrated that teen volunteers can be effective science teachers (Ponzio and Marzolla, 2002). Ponzio et al. (2000) concluded that this experience also had multiple pay-offs for the teen volunteers: teens' own learning of science is strengthened as they teach, teens practice the life skills of communication, planning, collaboration, and problem solving; and teens' psychosocial development is enhanced through the successful experience of teaching, a role usually reserved for adults.

Training Program Background

The idea behind the Young & Wild after-school program was not new. The author was a member of the University of Guelph (Guelph, Ontario, Canada) Wildlife Club. The Wildlife Club offered its members an opportunity very similar to the Young & Wild program, albeit more informal. Undergraduate student member of the Wildlife Club would present native wildlife, including snakes, to local school-aged children. Realizing the value of a club that provides biological science students with an opportunity to network and develop career-building skills, I designed Young & Wild with the intention of bringing this experience to secondary students who may not have the opportunity to benefit from a university-level program (Fig 4-2). From this program, secondary students could develop both the scientific knowledge and resume-building experiences for potential careers in conservation biology, research and education. Future pursuit of these types of careers is not improbable; several of the teen staff who participated in GreenNet, a project aimed at engaging low-income families in Santa Barbara, California in small horticultural business startups, pursued college educations in science or science-related fields (Ponzio and Marzolla, 2002).

Learners

The Young & Wild reptile educational outreach program began its inaugural year in February of 2010 at Eastdale Secondary and Port Colborne High School (PCHS), both Niagara region, Ontario, Canada, public secondary schools. Science teachers from

Niagara region public secondary schools were contacted via email and school locations were selected based on science teacher interest in participating in the program and schools' priority status by Census Canada. A priority school is one in which at least 16% of the population and students' families live under the poverty line. Schools in areas with high rates of poverty were given preference, in line with the mission of our community partner, the Education Foundation of Niagara (EFN). Thirteen students came to the first meeting and enrollment gradually decreased to six students who completed presenter training (4 female, 2 male). Students enrolled in the voluntary after-school program ranged from grades nine through 12. Three of the students told instructors that improving their public speaking was a motivation for joining the training program. Instructors noted that hands-on time with the animals was an obvious motivation. Many of the students enrolled were also involved in other after-school activities (sports teams, school clubs, and school concert band) and one was enrolled in a co-op program. Since the number of students gradually decreased, the instructors decided to merge the two schools into one group and transport students from Eastdale Secondary to PCHS because of more desirable facilities. Signed parental consent forms were received prior to transporting students.

Learning Environment

Training took place in a science classroom equipped with an LCD projector that was connected to a laptop. A Canon SX1 IS camera with a video recording setting was set up to record practice sessions for peer and instructor review. Desks in this classroom were arranged traditionally in columns, facing the front of the room as well as the projector. The front of the room had about five by ten feet of open space, which was necessary for practicing outreach presentations. The presentation set-up was designed to be very mobile as well as flexible so that presentations can take place in virtually any facility, even outdoors. All animals were transported inside one (49 x 43 x 39 cm) opaque case (Airline Transportation Association approved). This case was constructed by Custom Case (London, ON) and insulated and ventilated by Sciensational Sssnakes!!. The case features a lid, hinged to one side so that when open, the lid creates a barrier which allows a second presenter to get his/her animal ready without distracting the audience from the current presenter. Inside the case, snakes were transported in cloth bags tied with overhand knots, grouped in Rubermaid ® plastic boxes with ventilation holes. Turtles were transported within similar plastic boxes containing two to five cm of water that was changed as required. The desk set-up in this room was not ideal for group practices as students had to alternate between being an audience member and outreach presenter within minutes. It was difficult for students to move to the front of the room without disturbing the current speaker because of the arrangement of desks. A better set-up for group practices would allow the next presenter to easily reach the animal case without causing distraction. However, the LCD projector in this room was a major asset for video review and assessment.

Training Program Goals, Objectives, and Teaching Strategies

The learning goal of the training program was for secondary student volunteers to be able to effectively present educational outreach. A task analysis identified both cognitive and psychomotor abilities of an effective educational outreach presenter, and learning objectives were aligned to these tasks. Training strategies were developed and/or utilized to facilitate secondary students' achieving the learning goal (Fig 4-3). Table 4-3 outlines the original training program format prior to evaluation and revision;

Table 4-4 highlights the education literature which supports the strategies for student learning developed for this training curriculum.

Training Program Evaluations

Two separate evaluation instruments were used to assess the effectiveness of this new after-school program at training secondary students to present educational outreach. The evaluations were carried out to answer two questions: Can volunteer secondary students be trained to present effective educational outreach? And what were the strengths and weaknesses of the original design of this training program? The first evaluation instrument was a presenter evaluation rubric, which aligned directly with learning objectives for presenting effective educational outreach (Fig 4-4). This instrument was designed for formative and summative evaluations of the training program and was intended to answer whether students could present effective outreach. A connoisseur-based review of this evaluation rubric by C. Cavanaugh, an Instructional Design professor (University of Florida), confirmed this instrument’s usefulness for measuring presenter learning objectives. An additional summative evaluation of the training program curriculum was completed by working through the NAAEE *Nonformal Environmental Education Programs: Guidelines for Excellence* (2004), in order to determine the strengths and weaknesses of the original training program design. These guidelines shared many similarities with the ID method used to originally develop the Young & Wild training program from Morrison et al. (2007). The method of evaluation using the rubric and Nonformal Guidelines, statistical analysis, and results are discussed below.

Methods

Presenter evaluation rubric

The purpose of developing this evaluation rubric was to assess both the progress (formative evaluation) and overall ability (summative evaluation) of secondary students to present effective educational outreach. The rubric was distributed to secondary students and reviewed during the first meeting. The evaluation rubric provides student learners with standards for an effective outreach presentation, but also a tool for self-refection on their practice performances. It was explained to student presenters that while these evaluation tools may be helpful for self-reflection, they do not grade performance. The intention of these evaluations was not to criticize student presentations, but rather to inform the instructors of curricular components that may require additional review or revision. Formative evaluations using the rubric were completed by the instructors during three group practices. During community outreach presentations, adult audience members used the presenter evaluation rubric as a summative evaluation of student presenters' ability to present effective educational outreach. These rubrics, in combination with a review of Tyson's practitioner journal and students' videotaped practice sessions allowed for triangulation of the data. Practice videos had been saved from the second and third group practice session, as well as an additional fourth practice session which was added at the request of PCHS. PCHS students had been unable to attend the third practice due to a conflict with another after-school club meeting. Videos were reviewed by Tyson, one of the program designers and training instructors. Videos were reviewed once, noting effective presentation skills and areas for improvement (Table 4-6), according to the presenter evaluation rubric. Videos were reviewed a second time to assess whether the instructional message (the presentation material which tied to audience learning objectives, Table 4-1) was delivered effectively. Each speaking role (N=7) was reviewed independently. Most students presented two speaking roles in one practice presentation. Only evaluation rubrics were analyzed statistically. Administration of these rubrics was approved by the University of Florida IRB2 and written parental consent was received for collecting and reporting student data. Individuals were identified by a numerical code only known to researchers.

Alignment with guidelines for excellence

The NAAEE *Nonformal Environmental Education Programs: Guidelines for Excellence* (2004) highlights six key characteristics of high quality nonformal EE programs. Each characteristic lists guidelines for program developers to consider. Each guideline lists indicators or attributes to determine whether the nonformal program being developed or reviewed embodies the key characteristics. As a summative evaluation, this training program was compared to the guidelines for each of the six key characteristics in order to determine strengths and weaknesses of the original program design. These guidelines were also integral in the process of determining revisions to enhance the quality of this nonformal EE program.

Analysis

Presenter evaluation rubric

Presenter evaluation rubric scores were analyzed statistically for four educational objectives. When the outreach presentation was run through more than once in a single group practice, only the first performance was scored. All statistical analyses were performed using SPSS Statistics 17.0, and resultant p values were compared to an α-value of 0.05. Values are given as mean ± standard error, unless otherwise specified.

Objectives are discussed as 1-5, as numbered on Figure 4-4. Only objectives 1-4 were measured by instructors at group practices. Objective 5, assisting audience participants with touching and/or holding snakes safely, was not analyzed because it only occurred at community presentations. Presenters' scores on objectives 1-4 were compared using a repeated measures ANOVA with presentation date as a between-subject factor. When significant differences were found, individual means were compared by least significant difference (LSD) post hoc test. Trends in this data will be discussed. No presenter evaluations were distributed at the third community presentation because the audience members were primarily youth, ranging in age from 15-24 years.

Results

Presenter evaluation rubric

The results found that student presenters were achieving significantly higher scores on objectives 3 and 4 compared to objectives 1 and 2 ($F_{3, 24}$=11.678, $p<0.001$; Fig 4-5). Student presenters consistently were able to present themselves with professional appearance and demeanor (objective 3) and handle snakes appropriately and comfortably (objective 4). At community outreach presentations, student outreach presenters also scored very well (4.6 ±0.3) on assisting audience participants with touching and/or holding snakes safely and appropriately (objective 5). Overall, student presenters did not score as well on objectives 1, coming across as confident, and objective 2, effective public speaking. Removing students who dropped out of the program prior to completing training did not affect the significance of results ($F_{3, 19}$=11.362, $p<0.001$).

Interestingly, a qualitative analysis of Tyson's practitioner journal supported and confirmed patterns in the statistical analysis. On the day of the second group practice, Tyson wrote, “[Hathaway said] while some students are ready, some of the students are not ready to present in front of an audience. In my opinion, it's not [students’] ability to handle the animals properly, it's their comfort with the material and public speaking.” After the third group practice, Tyson wrote, “Students are still struggling with content. They often bail, seem nervous, and commonly end their talk with ‘and…that’s all I’ve got’.” The term bail refers to when a presenter leaves the stage abruptly and before completing content. Bailing often results from freezing up and/or forgetting lines due to nervousness towards public speaking. The practitioner journal supports and confirms the statistical findings that students were not able to master objectives 1 and 2 during training. The above quotes from the journal reveal that students were not able to meet the following criteria from the presenter evaluation rubric: comfortable with presentation material and clear enunciation and flow of speech. Tyson also refers to “student’s ability to hold animals properly”, supporting the statistical findings that students were able to master objective 4. There was no mention of students’ appearance and demeanor (objective 3) in the practitioner journal.

The qualitative review of presentation videos also supports statistical findings that students struggled most with objectives 1 and 2 during training. The reviewer noted the most areas for improvement in criteria that fell under objective 1, followed by objective 2 (see Table 4-6). Objectives 3 and 4 received very little constructive criticism. However, the reviewer also made the most positive comments regarding presenters’ abilities to effectively complete criteria under objective 1. Objective 2 had the second highest number of positive comments, followed by objective 3 and then 4. This trend suggests that it may be easier to recognize criteria under objectives 1 and 2 while a person is presenting outreach. This may be because criteria under these objectives are both visual and auditory. If this is the case, there may be a bias for scoring objectives 1 and 2 lower because criteria are easier to discern. In the future, evaluative scoring of presenters could avoid potential biases between objective scores by reviewing and scoring videotaped performances. Reviewing the videos several times would provide a more accurate portrayal of students' strengths and challenges while training to present educational outreach.

No strong patterns could be detected through review of the videos for changes in students' educational outreach presentation skills over time. The types of comments students' presentations received remained fairly consistent. The exceptions being that over time, slightly more presenters appeared comfortable with the species-specific presentation material and slightly less looked down at snakes instead of at the audience. Similarly, the second review of videos for the presence/absence of instructional messages (messages tied to audience learning objectives) had no visible trends or patterns over time (Fig 4-6). The qualitative review of group practice videos is supported and confirmed by the statistical analysis of presenter evaluation rubrics. Mean evaluation scores were not significantly different between the first three group practices or the first community presentation. However, the second community presentation had significantly higher evaluation scores than all other evaluated dates ($F_{4, 24}=4.763$, $p<0.01$). There was a trend of mean objective scores increasing slightly from practice session one (3.3 ± 0.1) to session two (3.6 ± 0.2), and from session two to session three (3.7 ± 0.3) but these improvements were not statistically significant. The largest improvement in objective scores was from the first community presentation (3.7

± 0.3) to the second community presentation (4.5 ± 0.1, $p<0.05$). This finding suggests that presenting in front of an audience is more effective at improving outreach presentation skills than group practices in front of peers. There is the possibility that audience members were more lenient than instructors in marking, but equal scores between the third group practice and first community presentation suggest that this was not an issue. Additionally, audience perception of the quality of educational outreach presented is perhaps more important than that of the instructors because they are, in effect, the consumers of the product being delivered. Additional comments written on presenter evaluation rubrics at the second community presentation were very positive, supporting secondary students' ability to present effective educational outreach. Comments included "Very well done" and "Presenter did a wonderful job even though he was nervous". No evaluator wrote additional comments at the first community presentation. Improving scores over time as well as positive comments by audience members suggest that volunteer secondary students can be trained to present effective educational outreach. Yet, these results should be interpreted with caution because inter-rater reliability was not assessed, leaving the possibility that the audience at the second community presentation scored presenters more leniently than the audience at the first community presentation. In the future, videotaping all presentations and evaluating presenters based on a review of the videos would provide more confidence in the reliability in scores of students' ability to present effective educational outreach.

Alignment with guidelines for excellence

Requirements for successful program implementation and challenges that arose from the original design are highlighted in Table 4-7. These training program elements are discussed in detail in the subsequent sections Requirements and Challenges.

Suggested revisions to the original design that may alleviate challenges are presented in the subsequent section.

Training Curriculum Requirements

The following describes in detail the elements of the original training program design which were essential for the successful implementation of the outreach training program:

Student Volunteer Information Session

The student information session was important in the success of this training program for several reasons. First, it promoted this new program to the target audience (volunteer secondary students) and it was a remarkable motivation for prospective volunteers. Thirty-three students signed up immediately following the information session and there was a palpable excitement from prospective participants. The key to the success of this information session was the use of live snakes and turtles and a hands-on session with snakes. The training instructor, Hathaway, demonstrated presenting reptile educational outreach and encouraged student sign-up with incentives of “this could be you presenting”, “I used to be afraid of public speaking”, and “it will be hard work, but also fun and rewarding”. Additional incentives included community service hours required for graduation, improved public speaking skills, and a unique resume-building experience. From the perspective of student learning, the information session gave learners an example of an effective educational outreach presentation.

Quality Instructional Staff

Effectively training student presenters would not have been possible without exceptional instructor quality. Hathaway’s expertise in presenting effective educational outreach as well as years of training outreach staff translated into a keen eye for noticing areas for improvement while students practiced presenting (e.g. distracting hand gestures, age-inappropriate vocabulary, and nervous habits). Additionally, an effective instructor can utilize strategies to help make learning meaningful and memorable such as first-hand stories (Davidhizar and Lonser, 2003). Hathaway would tell stories which included messages about recovering from embarrassing slip-ups, tips for engaging audience members through Q&A, tricks to try when lines are forgotten, advice for enhancing transitions between presenters, and suggestions for practicing at home. It was also important to have an experienced supervisor for the hands-on portion as a precautionary measure for any potential safety concerns or violations of rules that could cause injury to animals or people. A further benefit of having a professional educational outreach presenter as an instructor is that students are interacting with a role model as well as building a network within the EE sector. Arnold et al. (2009) found that five out of 12 youth environmental leaders listed role models, many from environmental or camp programs, as important influences in their transformation from interest into environmental action.

Quality Training Strategies

Three strategies are recommended for training teen educational outreach presenters: modeling, videotaped practices, and group discussion.

Modeling and group discussion

A combination of positive and negative models were used in the first group meeting when expectations of outreach presenters were being discussed as a group. The benefits of using both positive and negative models in a training program have previously been demonstrated (Baldwin, ’92). Hathaway modeled proper vs. improper handling of animals and students were quick to describe in their own words why the negative model was not an appropriate behavior. Responses that demonstrated student learning included, “it might hurt the animals” and “you wouldn’t want little kids handling the animals that way”. Similarly, Hathaway modeled proper vs. improper appearance by changing out of his outreach uniform into an old hooded sweatshirt. Learners described Hathaway as looking unprofessional and even commented that he looked less knowledgeable because of his clothes. Several students looked down at the clothes they were wearing and laughed, demonstrating an awareness of their appearance to an audience. Having students explain elements of the training curriculum in their own words allowed instructors to gauge the levels of learning and understanding but also allowed students to be metacognitive as they monitor their own ability to master skills and learn new knowledge. In hindsight, modeling could have also been used as a teaching strategy during group practice sessions. When students were struggling with content and effective public speaking an instructor could have paused practice to present a positive model.

Review of videotaped practices

The review of the videotapes during group practices served to provide student trainees with immediate feedback of their ability to present educational outreach. Instructors felt that learning was occurring during group review of videotaped practices based on students’ comments of their own performances. Students were usually quickest to shout out obvious areas for improvement such as crutch words and nervous gestures. Additionally, instructors would pause the video to pose questions to the group about less obvious criteria such as, “where was she looking” with the response being “at the snake, not at the audience”. Although much feedback was given during review sessions, it is unclear how much was retained; retention of knowledge and skills is vital for successful training. If students do not retain what they learn, improvements cannot be made in subsequent practices. Therefore, a revision to presenter materials should include short writing assignments for self-evaluation and reflection as a strategy to improve retention.

Collaboration with Community Partners

Working directly with funding agencies and community partners on the development of program curriculum not only enhanced stakeholder buy-in, it created additional learning opportunities for secondary students. Scientists from Ontario Power Generation spoke to secondary science classrooms about the importance of gaining practical experience and networking for career decision-making and professional development. Additionally, Ontario Power Generation facilitated a local after-school field survey for the threatened Jefferson salamander. Volunteer secondary students helped with specimen collection and learned about genetic techniques for species identification as well as land use policy for species at risk. These were both unique opportunities for secondary students to learn first-hand about scientific research, careers in science, and EE in nonformal settings.

“It Happens” Kit

The “It happens” kit is a necessity when providing hands-on sessions with live animals because the reality is that snakes are going to defecate, without warning, and possibly on a presenter or audience member. The kit includes hand sanitizer (which should also be used by presenters after handling turtles), paper towels, and extra cloth snake bags.

Challenges Arising from Original Curriculum Design

The following describes in detail the elements of the original training program design which created challenges for implementing the outreach training program:

Secondary Students Needs Not Met with After-School Training Program

Having training sessions after-school was not ideal for secondary student learners because of conflicts with other school activities and part-time jobs. This conflict was surprising to the program facilitators because the day of the week and time of after-school training were selected after an informal census at the information session. At least one prospective trainee could not attend training because of a part-time job, and several volunteers missed practice sessions because of school band practice and studying for exams. Nearing the end of the program, the science teacher at PCHS who supervised training sessions confirmed the difficulty of getting students to stay after school, even for help with homework, because they work. Students from PCHS came for help at lunchtime and even school clubs ran during lunch (Lucy Sardella, personal conversation, April 14, 2010). Forty minute lunch time training sessions would not be ideal for this program because it would not leave enough time for meaningful review of performance videos and subsequent group discussion. As it stood, fitting these higher-level tasks into hour-long practice sessions was challenging. The issue with after-school training may have been related to the schools' priority status. Pedersen and Seidman (2005) reviewed the participation of low-income youth in out-of-school activities and found that participation was consistently lower than youth from wealthier demographics. Since the potential benefits of this training program are high for at-risk youth (McNeal, '95; Mahoney, 2002), moving the program to a more affluent school is not an ideal solution. Better communication and collaboration between teachers and training instructors could have alleviated this challenge during early stages of program development by identifying conflicts with other after-school clubs and exam schedules (see Collaboration with school stakeholders below). However, the authors felt students' needs could be better met in a camp environment, outside of the school system.

Quality Student Presenters and Presenter Training Material

Instructors were generally pleased with students' handling of animals and were impressed with their ability to respectfully and appropriately help even nervous audience members touch and hold snakes. Yet instructors were surprised by the lack of ownership that some student presenters were taking in learning the reptile EE content, especially the instructional messages (Table 4-1). The number of facts to learn was minimal, with effective presentation of a species typically requiring under five minutes of talking. Although not formally assessed, instructors were confident that struggling students were not practicing verbal presentations at home. This notion was confirmed in a personal conversation between an instructor and one student presenter who admitted they did not review material at all outside of training.

In an effort to motivate struggling presenters to learn content, an abbreviated summary of the needs assessment was handed out midway through training. This handout described the need for presenting EE to elementary students as well as the aims of the secondary student presenters. This handout unfortunately seemed to be an ineffective motivator as students continued to struggle delivering instructional messages. Given the need for self-assessment in learning (Olson and Loucks-Horsely, 2000) a revision of this curriculum requires more guided self-reflection and evaluation opportunities, which will be discussed in revisions below.

Program Delivery

Although outreach presentations were originally designed for elementary student audiences during school hours, District School Board of Niagara (DSBN) administrators took issue with secondary students missing in-class time. The numerous potential benefits of secondary students presenting educational outreach at local elementary schools were presented, but administrators were unwavering in their decision. This decision came near the end of the training program and resulted in last-minute changes in program delivery format. The solution was after-school community presentations at local libraries and youth groups. This new delivery format did have several benefits. The first was that secondary students could obtain community service hours. In Ontario, secondary students are required to complete 40 hours before graduation. In addition to obligatory hours, positive interactions between secondary student volunteers and community members during outreach presentations may help foster citizenship education and a felt need for lifelong community involvement (Rhoads, ’98). Secondly, community presentations allowed for more inclusive program delivery. Community presentations at local libraries and a multicultural youth group reached a more diverse audience, both in age and cultures. A third benefit, which was a surprising positive outcome to program facilitators, was an opportunity for English language learners to practice speaking English while learning EE. The youth audience from the Welland Multicultural Centre consisted of young adults from age 15 to 24, many of whom were new to Canada and English language learners. During the hands on-session, the room was filled with excited chatter in many languages as friends coaxed each other to touch and hold a snake and pose for a photo. Audience members asked presenters many questions about Ontario snakes and local conservation.

Collaboration with School Stakeholders

Stakeholder buy-in and participation in the development and early implementation of new nonformal EE program is essential for program success. This training curriculum was designed with minimal consultation or collaboration with school stakeholders which resulted in many of the challenges to the program's implementation. An initial meeting with a Niagara secondary school head of science in the summer of 2009 identified a need from teachers to have a condensed training program rather than a weekly after-school club as the program was originally designed. This need was due to teachers' time constraints from workload and assistance with after-school programs already in existence. A meeting with the head of science from Eastdale Secondary in January 2010 confirmed that a condensed four week training program better met teachers' needs. These two meetings were the extent of consultation with school stakeholders. In hindsight, this was an obvious oversight and contributed to many of the program's challenges. For one, early consultation with DSBN administrators would have alerted program developers of the issue with secondary students missing in-class time. Perhaps collaborating with DSBN administrators early on could have resulted in a compromise where presenters could miss a single day of in-class learning for elementary school presentations. Many secondary students miss in-class time for other school-related activities (e.g. school sports and field trips) and working directly with school stakeholders may have facilitated this outcome. An additional loss from the restriction to after-school training was that the proposed in-class dress rehearsal for a grade 9 audience had to be replaced with a third group practice session. This change was again unfortunate for the development of secondary student presenters. Our results support the value of presenting in front of an audience at improving secondary students' ability to present effective educational outreach.

Secondary school teachers and principals were in support of an in-school elementary school presentation, noting that it would be a beneficial learning experience. Yet for the most part, teacher involvement with student training was minimal and mostly involved passing messages from instructors to students between meetings. Often communication breakdown occurred and messages would not be received. It was unfortunate that teachers did not take an active role in the program, Stern et al. (2008) found that students whose teachers were actively engaged in an EE program had significantly more positive learning outcomes, including increased long-term environmental awareness. A participatory approach to curriculum development and/or evaluation involving school stakeholders may have resulted in teachers feeling increased ownership over the program and a willingness to take on more responsibility. Participatory approaches to curriculum development have aided EE programs at addressing preconceptions, meeting the needs of both learners and facilitators, increased stakeholder involvement, and collaboration among stakeholders to improve programs (McDuff, 2002; Peters and Matarasso, 2005; Somers, 2005). In particular, Somers (2005) found that a participatory approach to evaluation of a nonformal EE program fostered information sharing among program administrators and program staff and resulted in increased stakeholder buy-in.

Training Facilities

Issues with classroom training facilities were briefly discussed in Learning environment above. However, an additional difficulty arose from transporting student presenters from Eastdale Secondary to PCHS when training was merged to one facility.

Since instructors had no direct communication with secondary students outside of training, instructors were frequently unsure of whether a student was late or would be absent that day. This invariably caused instructors to arrive at PCHS late. With the tight training schedule, practices ran long and drop-offs at Eastdale were often 30 minutes later than scheduled. Thankfully, no parents expressed anger or frustration to instructors for having to wait.

Sustainability

An original aspiration of this program, developed in collaboration with funding agencies, was sustainability. Sustainability was defined as the program continuing to run in subsequent years. Unfortunately, given the lack of communication or collaboration between program facilitators and school stakeholders, continuing this program within the DSBN does not appear to be a viable option without considerable consultation.

Revised Training Program Curriculum

The challenges of this program’s inaugural year lead the authors to propose three major revisions to improve program curriculum and better meet secondary students’ needs: (1) a presenter handbook, (2) presenter tryouts, and (3) incorporation into environmentally oriented camp environment.

Presenter Handbook

Presenter materials were originally handed out to students as loose papers. Often students would misplace materials or forget them at home. A presenter handbook would organize materials allowing for easy reference, and prevent loss of individual pages. A presenter handbook could also be developed as a tool for student learning by including questions with space to record self-evaluation and self-reflection. Self-assessment is especially valuable when the format is personal such as reflective logs, diaries, and action plans (Race, 2001). Time could be incorporated at the end of group practices for students to record answers to handbook questions (Fig 4-7). Additionally, students could discuss their answers as a group to promote peer learning.

Presenter Tryouts

If interest in presenting educational outreach is high, a tryout for speaking roles could be added after the first group practice. Our outreach presentation had the capacity for nine speaking roles, with the potential for adding additional roles by increasing the number of species presented. Tryouts for individual speaking roles (e.g. presenting the black rat snake) is a strategy for improving student ownership over learning species-specific material. Only those students who demonstrated that they have learned the presentation material would be selected for delivering outreach presentations. Students who were not selected could train as understudies and help during hands-on sessions. The benefit of tryouts is that instructors will only be training dependable students. The downside is that students who currently struggle with public speaking may not have opportunities for improvement.

Incorporation into an Environmental Camp

Table 4-8 presents a revised training schedule for a camp environment. Changing the learning environment from a school classroom to an environmentally oriented camp has several benefits. The first is program coordination. Students would be dropped off and picked up daily or weekly by parents, eliminating the facilitators' challenge of transporting students from multiple schools to one training location. This in turn could increase the number of secondary schools involved, increasing the program's impact. Additionally, if the camp was residential student attendance would no longer be a concern. Student trainees would be at the camp all week. Parental consent forms would be part of camp registration. Costs of animals, instructors, presenter handbooks, and T-shirts could be incorporated into camp fees, decreasing the dependence on external funding agencies. If the target learners are students from low-income families, bursaries could be granted or fees could be waived. A consideration of incentives for low-income or underrepresented students is important because youth environmental leaders are more frequently White females and generally not from low-income backgrounds (Arnold et al., 2009). A camp facility is also a sustainable environment for this training program, with the potential for new students to enroll each year.

Training at a camp would better meet secondary students' needs because sessions would not be running after school. Training would not conflict with after-school clubs or studying for exams. A camp facility would also satisfy school board administrators because no in-class time would be missed. Running this program through an environmentally oriented camp could actually strengthen learning outcomes in environmental attitudes, knowledge, and action as these gains have previously been demonstrated at residential EE programs and structured outdoor camps (Stern et al., 2008; Arnold et al., 2009). The camp facility could host a community educational outreach presentation as part of an open house on the final day of camp. Additional community presentations could be scheduled if desired.

Conclusions

The goal of this study was to present the framework for a nonformal EE program in which volunteer secondary students presented educational outreach to community audiences. No new program design is ever perfect, but the lessons learned in Young & Wild's inaugural year can inform future educational outreach programs. Secondary student trainees were able to safely and professionally assist community audiences with touching and holding Ontario snakes; thus allowing community members to build awareness, knowledge, and positive attitudes towards Ontario reptiles. Involvement in this program enabled these students to move from environmental awareness to community-oriented environmental action. This transition to environmental action requires positive role models, experiences with nature, and strong EE programs (Arnold et al., 2009). The summative evaluation has identified required revisions to this outreach training program. For one, trainee self-reflection and self-evaluation strategies may help future students learn their lines more easily. Secondly, a failure to incorporate participatory approaches to curriculum development lead to communication breakdown between program facilitators and school stakeholders which resulted in challenges to the program's implementation. However, a critical issue was that secondary student learners' needs were not being met in an after-school environment. Incorporating this training program into an environmentally oriented camp will not only enhance students' environmental education, it will alleviate conflicts with after-school clubs and studying for exams. An environmentally oriented camp could provide a sustainable facility for a yearly training program, allowing for continual evaluation and further curricular improvements. Additionally, long-term effects could be evaluated for both student participants and community audiences.

Resources

A Quick Reference Guide to Ontario Snakes, *A Quick Reference Guide to Ontario Turtles*, *A Quick Reference Guide to Helping Amphibians and Reptiles*, and Ontario Elementary School Curriculum Materials can be accessed on Scales Nature Park website: http://www.scalesnaturepark.ca/resources.html

Please contact T. Tyson for additional presenter materials from the Young & Wild training program.

Table 4-1. Community presentation curriculum: live reptile species presented as learning tools. Verbal presentation material (instructional message) about each species ties directly to audience learning objectives. Note that learning objectives have been shortened from the original versions for simplicity. Timeframes, provided instruction and materials, and measurements have not been included.

Species of Reptile	Audience Learning Objective	Instructional Message
Garter Snake	Learners will increase positive attitudes towards reptiles	Snakes are not “cold blooded” Negative connotation like “cold-blooded killer” Ectotherm is a better term
Northern Water Snake	Learners will increase positive attitudes towards reptiles	Forked tongue for smelling with direction Not “evil” like pitchforks
Milk Snake (bridge to discuss Massasauga Rattlesnake)	Learners will not kill reptiles out of fear or for sport Learners will support conservation of existing habitat via financial support, personal time (volunteering), and political support	How dangerous are rattlesnakes? Massasaugas only killed 2 people in recorded history, last was 45 yrs ago (compare to cars) Safest to keep a distance, not approach with a shovel! What is a species at risk? Not many left, only found in special areas like Wainfleet Bog (local example)
Black Rat Snake	Learners will support the creation of new habitat and habitat restoration projects via financial support, personal time (volunteering), and political support.	Population declines due to forest habitat loss What can I do? Plant trees!
Blanding's Turtle and Snapping Turtle	Learners will be able to safely help a turtle cross the road	Population declines, mother turtles cross roads to lay eggs, hit by cars How to safely (for you and the turtle) help a turtle cross the road
Corn Snake	Learners will not take wild animals home as pets	Leave wild animals in the wild (against the law to take home) Example of a good pet snake, bred in captivity

Table 4-2. Rules for handling snakes, presented to audience participants at the end of the verbal portion of the presentation, prior to the hands-on session.

Rule	Rationale
No scaring anyone	People could get hurt
No hissing noises, etc	Snakes could get hurt
No tolerance for scaring	
Snakes will be put away, hands-on will be over	
Don’t squeeze or restrain	Live animals, could get hurt
Move slowly and gently	Pulling backwards hurts scales, like bending a fingernail back
Unwind or unwrap, never pull	
Support snake’s whole body at all times	Snakes used to having whole belly supported by ground/tree
Create flat surface with hands, use neck/shoulder for climbing species	Tip: a snake that sits still is being handled well
Don’t dangle body like skipping rope	
Don’t drop snakes	Fall to floor could kill a snake
No snakes on floor, tables, chairs	Stepped on or sat on
In hands at all times	Flat snakes are not healthy snakes
Done? Pass to someone else or back to presenter	

Table 4-3. Original schedule for secondary student presenter training. This schedule was later modified through formative and summative evaluations. * Denotes elements of curriculum design that would later be revised. See Table 4-8 below for a revised curriculum.

Meeting	Strategies used and Material Covered/Reviewed	Time allotted
Information Session (week 1)	Instructor models delivery of outreach presentation Secondary student audience selected by science teachers due to interest and/or maturity Q & A	1 hr
First Meeting (week 2)	Instructors present schedule for training format for outreach presentations* Presenter material* discussed as a group: Presentation curriculum (Table 2), quick guides for Ontario snakes, turtles, and helping amphibians and reptiles (see resources for online material), tips for public speaking, parental consent forms, presenter evaluation rubric (Fig 1) Students selected primary and secondary species to present	1 hr *
Group practice 1 & 2 (weeks 3 & 4)	Independent review of presentation material Videotaped group practice, instructors evaluate performances with rubric Video watched once in silence Video reviewed, group discussion- peer and instructor feedback of positive improvements/ needs work	1 hr/ week*
Dress rehearsal* (week 5)	In-school, grade 9 audience Verbal presentation, modeling animals Hands-on session	1 hr
Elementary school presentations* (week 6 +)	In-school, elementary audience Verbal presentation, modeling animals Hands-on session	1 hr

Table 4-4. Strategies for secondary student outreach presenter learning, supported by education literature. *See Figure 4-4 for a list of training program learning objectives

Learning Goals and Objectives*	Training Curriculum Strategy	Education theories, concepts, findings
Students present effective educational outreach (training program goal)	Example (model) of effective outreach presentation	Social learning theory- students will learn by modeling their behaviour on the behaviour of the instructor (Morrison et al.,2007).
	Standards for excellent outreach presentation (presenter evaluation rubric)	"[O]bjectives guide the learner. The rationale is that students will use the objectives to identify the skills and knowledge they must master" p. 104 Morrison et al. 2007
	Group discussion	-Collaborative learning is a method which has students working together in small groups towards a common goal. Group discussion promotes critical thinking, enhances learner motivation, and allows students to learn from one another (Johnson & Johnson, '86; Gokhale, '95). -In cognitive modification, students discuss fears about public speaking and one-by-one those fears are discussed as irrational beliefs that need to be replaced by rational beliefs, an effective tool for reducing public speaking anxiety (Allen et al., '89).
	Formative assessment	-Formative assessment provides immediate feedback to learners in order to "improve learning while it is happening" (Topping, '98). -For public speaking, formative assessment involved practice speeches with constructive criticism, an effective tool for reducing public speaking anxiety (Allen et al., '89).
	Peer feedback (review of videotaped presentations)	-Peer review advances student learning, developing reflective processes like critical thinking (Topping, '98). Students who have completed peer assessments of outreach presentations are in a better position to assess their own communication presentation skills (Race, 2001)

		-Students involved in peer assessment have been found to be highly motivated and interested in the task (Stefani, ‘94) -Peer assessment is also seen as an employable skill in some fields (Hughes and Large, ‘93)
	Self-Evaluation (review of videotaped presentations)	“Engaging students in assessment of their own thinking and performance allows them to be more self-directive in planning, pursuing, monitoring, and correcting the course of their own learning.” p. 80, Olson and Loucks-Horsely, 2000. -Self-assessment promotes high motivation and interest in the task. Learners develop a realistic sense of their own strengths and weaknesses. Surveyed students felt self-assessment made them think more and learn more than traditional assessment (Stefani, ‘94)
	Dress Rehearsal	A dress rehearsal in front of a familiar and pleasant audience is an effective strategy for decreasing public speaking anxiety (MacIntyre & Thivierge, ‘95)
Professional Appearance and Demeanour Handling snakes appropriately and comfortably	Positive/negative modeling	The use of positive/negative models in a training program enhanced understanding of concepts and resulted in increased ability to transfer skills to a novel context (Baldwin, ‘92)
Come across as confident in front of audience Effective public speaking	Personal History Storytelling	-Storytelling techniques, including personal history, have long been used by teachers to instruct, illustrate, and guide student thinking (Zabel, ‘91). -Storytelling is an effective strategy for teaching character education (Sanchez et al., 2009). -Storytelling engages learners’ personal experiences and beliefs; also allows learners to vicariously benefit from the experience of an expert (Davidhizar and Lonser, 2003) -Storytelling as a teaching strategy is a powerful tool for making sense of the world and experience (Egan, ‘88).

Table 4-5. List of comments noted during the review of presentation videos. Positive comments fell under “effective presentation skills” and constructive criticism fell under “areas for improvement”. These comments related to criteria for each learning objective, in parentheses.

Effective presentation skills	Areas for improvement
Engaging stage presence (asked audience questions) (1)	Umms/uuhhs (crutch words) (1)
Made eye contact with audience (1)	Looking down at snake, not up at audience (1)
Good transition to next presenter (1)	Not comfortable with presentation material (1)
Comfortable with species-specific presentation material (1)	Weak transition to next presenter (1)
Good volume (2)	Bailed (just walked off) (1)
Good tone of voice (2)	Distracting gestures (playing with hair, fiddling with clothes/snake) (1,2)
Good flow of speech (2)	Choppy/ nervous flow (2)
Enthusiastic/ cheerful attitude (2, 3)	Not enthusiastic (2)
Appropriate clothing and hair (3)	Not showing snake to audience (4)
Comfortable holding snake/turtle (4)	Inappropriate vocabulary (2)
	Unprofessional appearance (backwards hat) (3)

Table 4-6. Review of most frequent presenter attributes from the presentation videos. Criteria relate to specific learning objectives, in parentheses

Effective presentation skills	areas for improvement
1.Comfortable with species-specific content (1)	1.Crutch words: umms, uuhhs (1)
2.Handles snakes appropriately and comfortably (4)	2.Weak transition to next presenter: “That’s all I know”, “That’s about all/it”, “That’s pretty much it” (1)
3.Enthusiastic/positive attitude (2, 3)	3.Looking down at snake, not at audience (1)
4.Appropriate volume (2)	4.Choppy/nervous flow (2)

Table 4-7. Summative Evaluation using the NAAEE *Nonformal Envirionmental Education Programs: Guidelines for Excellence*. Requirements for successful implementation of this training program are highlighted in yellow and challenges associated with the original design are highlighted in green.

Key characteristics from NAAEE Nonformal Guidelines	Summative evaluation: Requirements and challenges of program curriculum
1.Needs Assessment	Environmental need confirmed with local environmental stewartship and nonformal environmental education centre Program development built on Sciensational Sssnakes!! training program and materials from Reptiles at Risk on the Road (see resources) Secondary Student volunteers needs not met with after-school training program
2.Assessment of Organizational Needs and Capacity	In-line with mission of EFN, low income student opportunities Only science-based initiative of EFN Program supported by EFN staff and board members
3.Determination of Program Scope and Structure	Audience goals and objectives defined and addressed in presentation curriculum (Fig 4-1 & Table 4-1) Student presenter goals and objectives defined and evaluated with rubric (Fig 4-4) Program compliments and enhances Ontario Environmental Education Curriculum (Ministry of Education, 2009) Additional program goals (student career development, community service, sustainability) built into program curriculum and achieved through collaborations with community partners Program delivery Collaboration with school stakeholders
4.Program Delivery Resources	Budget covered costs of animals, instructors, printed materials, T-shirts, and transportation Quality instructional staff Quality volunteer student presenters Training facilities “It happens” kit
5.Program Quality and Appropriateness	Presenter training materials (see Fig 4-4 and resources) Quality training strategies (see Fig 4-3 and Table 4-4) Student volunteer information session Sustainability
6.Evaluation	Formative and summative evaluations (see Fig 4) Use results to inform program revisions

Table 4-8. Tentative training schedule: incorporating a reptile educational outreach presenter training program into a week-long camp.

Day	Material covered	Time required
Day 1	Information session	1 hr
Day 1	Presenter information, presenter handbooks	1.5 hrs
Day 2	Group practice, videotaped and reviewed as a group -suitable for max. ~20 secondary students	2 hrs
Day 3	Tryouts (optional) or group practice, videotaped and reviewed as a group ~10 speaking roles + understudies and hands-on session helpers	2 hrs
Day 4	Group practice, videotaped and reviewed as a group	2 hrs
Day 5	Dress rehearsal in front of camp members (optional)	1 to 1.5 hrs
Day 5 or 6	Presentation for families and invited community members	1 to 1.5 hrs
Following week-long day camp	Additional evening community presentations (optional)	1 to 1.5 hrs

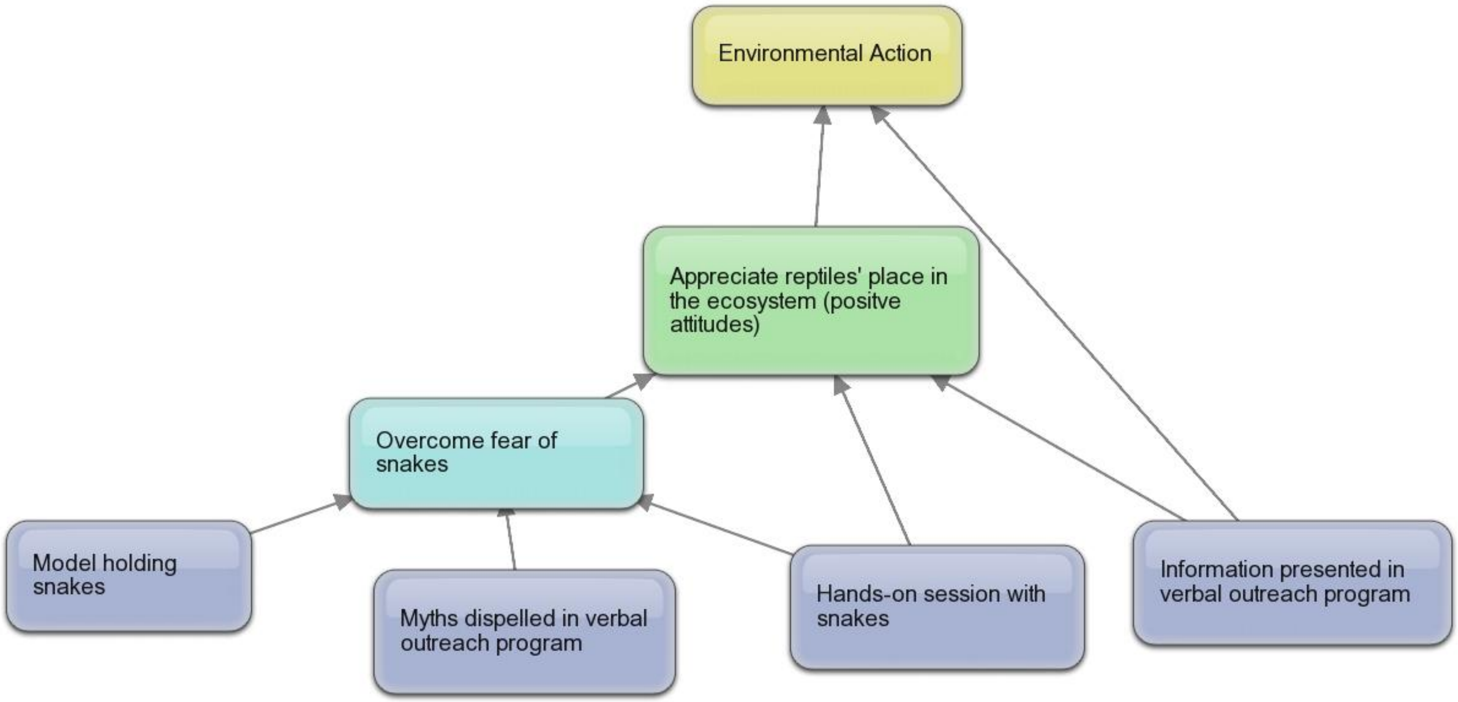

Figure 4-1. Theories of change diagram, illustrating the necessary pre-conditions for progressing to the long-term audience goal (yellow). Presentation strategies (purple) first addressed behavioural changes (blue) in order to achieve the short-term presentation goal (green). A combination of knowledge and shift towards positive attitudes is required for audience participants to become conservation-oriented adults who change behaviours which directly or indirectly lead to reptile species declines.

Vision for Young & Wild Program: Positive Benefits for Seondary Students

- Bring a teaching role, generally reserved for adults (educational outreach presenter) to secondary students (Ponzio et al., 2000).
- Provide secondary students with unique career-building experiences:
    - Networking with peers and local scientists
    - Resume-building positions (Educational outreach presenter, field assistant, community service, etc.)
    - Knowledge of local species at risk, environmental education, policy, conservation, and restoration

Figure 4-2. Underlying philosophy behind the curriculum development and start-up of the Young & Wild after-school program.

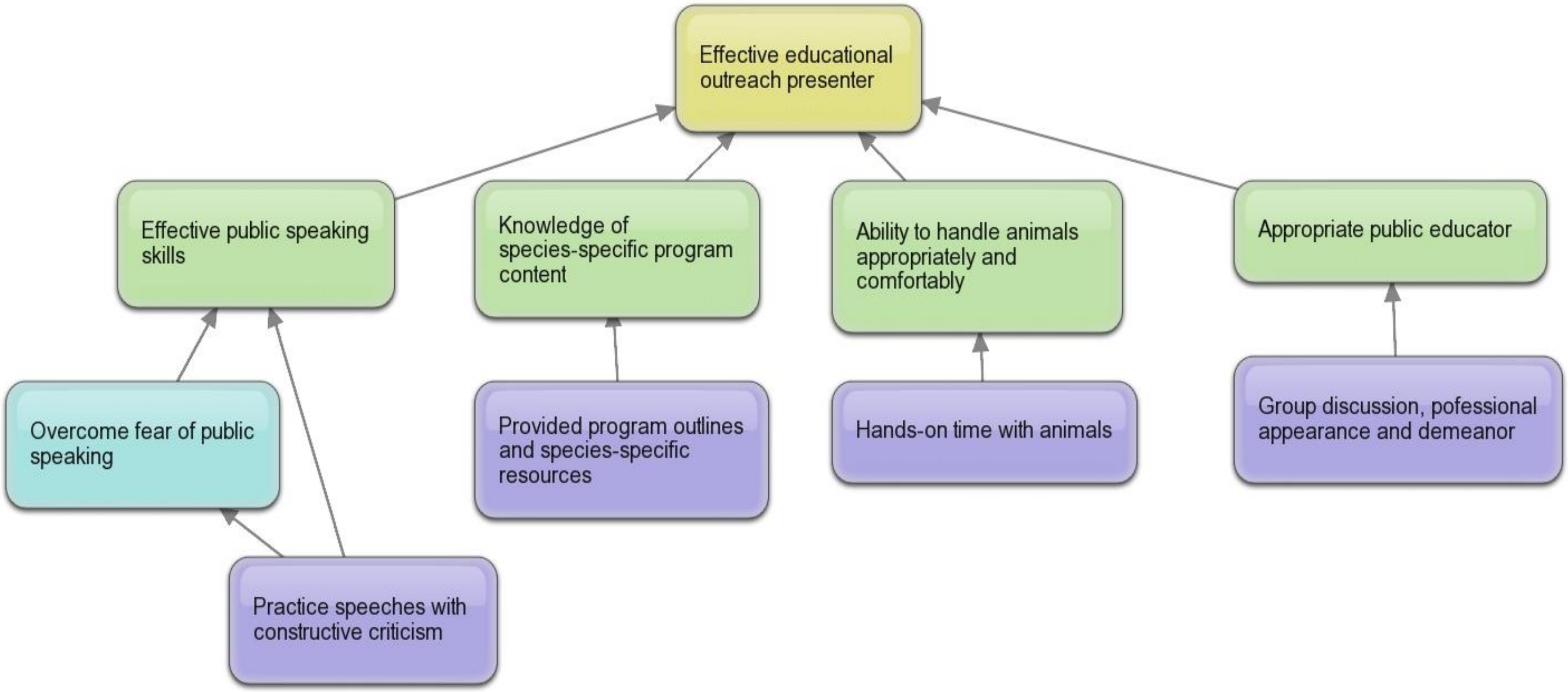

Figure 4-3. Theories of Change diagram, illustrating the necessary pre-conditions for progression to the long-term training goal (yellow). Training strategies (purple) should facilitate behavioural changes (blue) and learning objectives (green). Learning objectives must be achieved in order to realize the long-term goal of effective educational outreach presenters.

Presenter Evaluation Rubric Presenter:______________________________

Please score the presenter from 1 (lowest) to 5 (highest). A description of level 5 is provided for each objective. Descriptions include 5 criteria for each objective.
If presenter meets 4/5 criteria their score is a level 4, etc.

Objective	1	2	3	4	5	Description of level 5
1. Presenter comes across as confident in front of audience members						-avoids repetitive/distracting nervous gestures -avoids crutch words (umms, like, etc) -comfortable with presentation material -makes eye contact with audience members -has an engaging stage presence
2. Effective public speaking skills						-appropriate volume (not too loud/not too quiet) -clear enunciation and flow of speech -enthusiastic -avoids repetitive/distracting gestures -use of age-appropriate vocabulary
3. Presenter has a professional appearance and demeanor						-proper attire (clothing has no rips, no slogans, wearing project T-shirt) -clean and neat -appropriate hair (out of face, not messy) -polite (no profanity) -cheerful/positive attitude
4. Presenter handles snakes appropriately and comfortably						-not nervous -proper support of snake at all times -slow, gentle movements - handling appropriate for species -lack of restraint
5. Presenter assists audience participants with touching and/or holding snakes safely and appropriately						-attentive to audience members -demonstrates proper handling to audience -provides reminders of rules -provides proper encouragement for touching snakes (not forcefully encouraging touching) -appropriate intervention when necessary

Additional Comments:

Figure 4-4. Presenter Evaluation Rubric

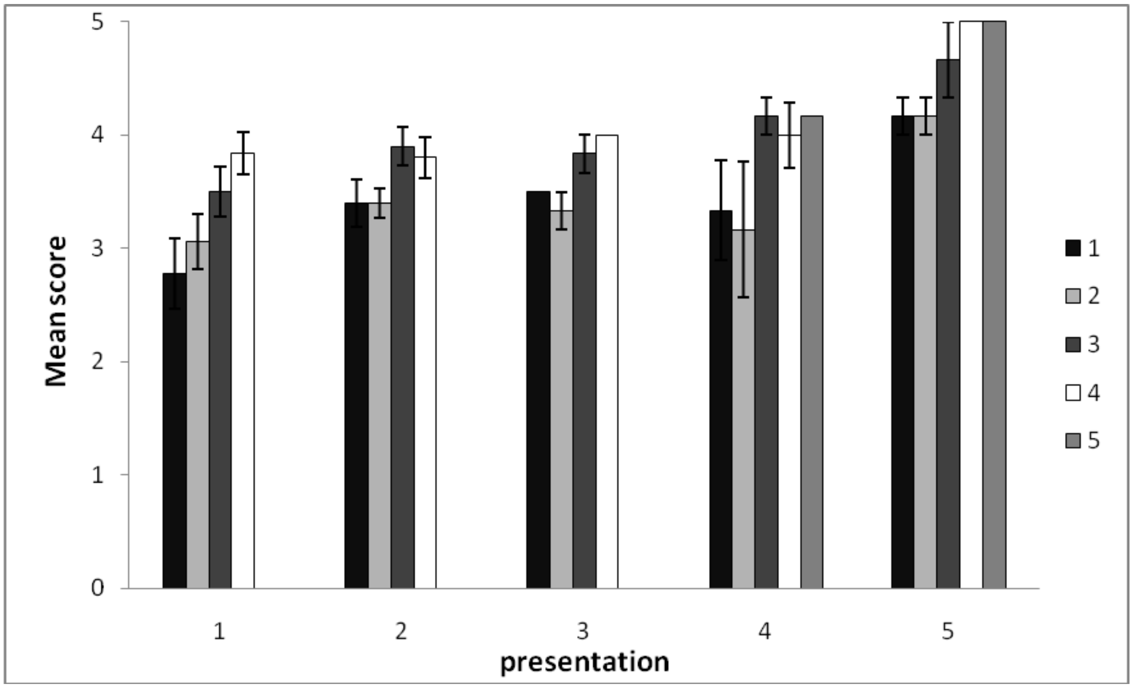

Figure 4-5. Mean objective scores on presenter evaluation rubric by presentation. Standard error bars shown. Objectives are as follows: Objective 1: Presenter comes across as confident in front of audience members; Objective 2: Effective public speaking skills; Objective 3: Professional appearance and demeanour; Objective 4: Handles snakes appropriately and comfortably; Objective 5: Assists audience members with touching and/or holding snakes safely and appropriately. Presentations 1-3 were group practices and presenters were scored by program instructors. Presentations 4 and 5 were community presentations and presenters were scored by adult audience participants. Number of presenters at each presentation are as follows: Presentation 1 (n=9), Presentation 2 (n=7), Presentations 3-5 (n=3).

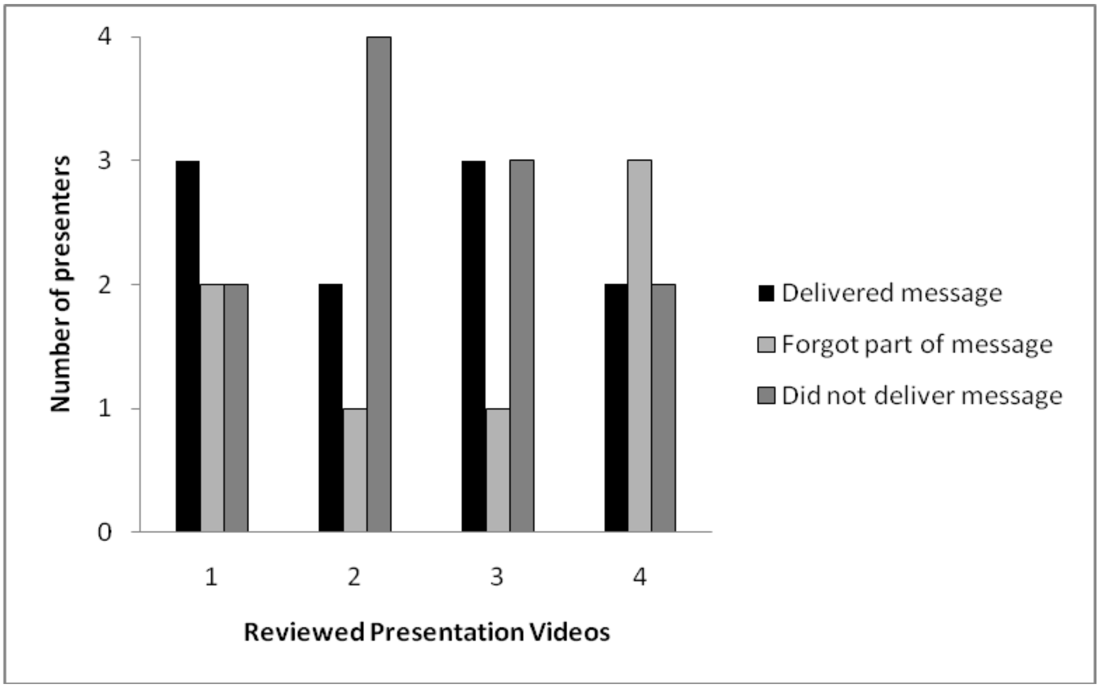

Figure 4-6. Second review of presentation videos for presence/absence of instructional message (Table 4-1). All presentations had 7 speaking roles which were reviewed independently. Videos 1 and 2 were from the second group practice session with N=9 students. Video 3 was from the third group practice and had N=3 students. Video 4 was an additional (fourth) group practice, N=6 students, added following poor attendance to the third group practice. If a presenter delivered all the necessary facts for the instructional message they were scored as “delivered message”. If the presenter only presented some of the facts for the instructional message they were scored as “forgot part of the message”. If a presenter delivered none of the facts for the instructional message they were scored as “did not deliver message”.

- What did you like about your performance today?
- What objectives from the presenter evaluation rubric are you struggling with?
- List ways you can practice this week to work on improving your presentation.
- Think about last week's practice, what objectives have you improved on? How do you know? What makes you feel that way?
- Think about other students' performances. Describe at least one thing you liked about someone else's performance.
- Think about presenting in front of an audience. What are you worried about? What can you do this week to minimize those worries?

Figure 4-7. Sample self-evaluation and self-reflection questions for secondary student educational outreach presenter handbook.

CHAPTER 5
CONCLUSION

This study of the relationship between environmental temperature and the rate of limb regeneration demonstrates that environmental changes alter ectothermic animals' physiological functions. Furthermore, preference trails revealed that red-spotted newts prefer stable environmental temperatures while regenerating. This behavioral thermoregulation around a narrow temperature range may be a strategy to avoid the immune system depression caused by variable environmental temperatures (Raffel et al., 2006). However, human actions have lead to climate changes which are detrimental to ectothermic animals. This effect is evident in the global declines of amphibians and reptiles caused either directly or indirectly by human behaviors (Gibbons et al., 2000; Collins and Storfer, 2003; Sodhi et al., 2008).

The goal of environmental education (EE) is to educate people so that they decide to replace detrimental behaviors with those that are positive or beneficial for the environment (Peters and Matarasso, 2005). Therefore, it is essential for EE to target children and youth. If today's youth are encouraged to learn about, value, and protect the environment, wild animals, such as amphibian and reptile populations, and natural spaces will be sustained for future generations.

Such a goal can be accomplished through environmental outreach programs like Young & Wild which actively involve teenagers and provide hands-on learning for children. Through a hands-on educational outreach program that uses live animals, audience members and presenters alike can experience the prerequisites to environmental action. In Young & Wild presentations, people became aware of animal species that they did not know existed, they gained knowledge of these animals' physiology, ecology, and anatomy, their preconceived negative attitudes were challenged through the hands-on session, and they learned the skills required to take environmental action such as planting trees or helping turtles cross the road. UNESCO ('78) identified this progression from awareness, knowledge, attitudes, and skills as the stepping stones to positive environmental action (Jacobson et al., 2006). The continuation of educational outreach programs like Young & Wild will hopefully inspire and enable researchers to continue to study amphibians and reptiles while allowing future generations to experience amphibians and reptiles in their natural habitats.

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BIOGRAPHICAL SKETCH

Teala M. Tyson graduated with an honors degree in zoology from the University of Guelph, Ontario, Canada in 2007. She studied herpetology and did a research project on regeneration in the red-spotted newt. She continued regenerative research for her Master of Science. Tyson had summer jobs working with children through high school and university and became interested in Science Education during her master's.