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Empirische Studie zur Steigerung des kognitiven Wissens und der positiven Wahrnehmung von Bienen

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INHALTSVERZEICHNIS

Aus Gründen der besseren Lesbarkeit wird an einigen Stellen im Text auf die gleichzeitige Verwendung männlicher und weiblicher Sprachformen verzichtet. In diesem Fall gelten die Personenbezeichnungen gleichwohl für beiderlei Geschlecht.

1 SUMMARY

Due to the current loss of biodiversity all over the world caused by human impact, especially pollinating animals hog the limelight in public, research and policy. A loss of pollinators would lead to negative effects for mankind and nature. Education focussing on conservation of biodiversity, especially of pollinators, presents an effective tool on local level in order to counteract these global challenges. In spite of their essential ecosystem service and the urgent need for actions due to recent losses, pollinating insects such as bees and other hymenoptera species are perceived as frightening creatures. This leads to a problem as negative emotions such as disgust or fear are assumed to hinder effective environmental education. Consequently, besides supporting knowledge, attitudes and participation in educational initiatives, it is necessary to focus on these negative perceptions and counteract them with positive experiences.

The empirical study analysed potential effects of an educational programme for secondary schools, which was supposed to foster positive perceptions and environmental relevant knowledge with the honeybee (*Apis mellifera*) as exemplary organism. The effectiveness of two different methodological approaches was evaluated: Firstly, encountering living bees at a local beehive and secondly, using a digital tool that allows visiting a remote beehive.

Previous studies point to an existing discrepancy between the individual willingness to protect animals as well as wildlife and their attitudes towards the respective species. Hence, the first sub study (Study A) monitored existing attitudes towards bees concerning perceived danger, interest and the conservational concerns of school and university students as well as of beekeepers as a reference group. The perceived danger clearly correlated with the willingness to protect bees. Although perceptions were found as overall positive, individual experiences and the knowledge about the bees' capacity to sting were nevertheless the most prevalent reasons for a perceived danger.

All further sub studies are based on the participation in the developed educational module on the achievement and importance of honeybees. Overall about 350 students completed the different student-centred learning stations, which were implemented following two methodological approaches. In both interventions, students' perception of bees were influenced positively with a lasting effect: Besides reducing the perceived danger and increasing interest for bees, the willingness to protect bees as pollinators was fostered in both cases (Study B). Moreover, both approaches supported the acquisition of environmental relevant knowledge about bees (Study C).

Surprisingly no effects of the perceived danger on the acquisition of knowledge could be detected. However, students with lower ‘green’ attitudes could be especially addressed through the tasks with the online beehive with regard to cognitive achievement.

Encountering the living bees at the beehive in the school grounds evoked more positive situational emotions compared to the work with the remote beehive via eLearning. This fact and further benefits underline the need of direct experiences in terms of encountering living animals. However, the use of digital tools in environmental context constituted a valuable alternative as eLearning could also support cognitive achievement as well as positive attitudes and emotions. Through measuring additionally students’ computer-related self-concept, the adequacy of the use of digital tools in secondary school was proven (Study D). As participants showed a sufficient high self-concept, it was shown that using the online beehive is suitable to provide an effective learning process.

2 ZUSAMMENFASSUNG

Angesichts des weltweit anhaltenden Biodiversitätsverlusts durch anthropogene Einflüsse rückt besonders die Gruppe tierischer Bestäuber in den Fokus von Öffentlichkeit, Forschung und Politik. Denn ein Verlust von Bestäubern hätte drastische Folgen für Mensch und Natur. Auf lokaler Ebene sind Bildungsangebote zum Erhalt von Artenvielfalt, insbesondere von Bestäubern, eine effektive Möglichkeit diesen globalen Herausforderungen zu begegnen. Trotz ihrer Ökosystemleistung und des dringenden Handlungsbedarfs gelten bestäubende Insekten, vorrangig Bienen, als mit Angst assoziierte Tiere, was einer erfolgreichen Umweltbildung im Weg stehen kann. Zu diesem Zweck ist es notwendig, dass entsprechende Bildungsmaßnahmen neben der Förderung von Wissen, Einstellung und Engagement auch auf jene negativen Wahrnehmungen eingehen und diese mit positiven Erfahrungen kontrastieren.

In der vorliegenden Studie wird aus diesem Grund ein schülerzentriertes Unterrichtsmodul für die Sekundarstufe vorgestellt, das am Beispiel der Honigbiene (*Apis mellifera*) positive Wahrnehmungen und umweltrelevantes Wissen fördert. Dabei wurden zwei verschiedene Zugänge evaluiert, die direkte Erfahrung mit Bienen an einem Bienenstock und der Einsatz digitaler Medien, die über eine eLearning-Plattform den virtuellen Besuch eines realen Bienenstocks ermöglichten.

Aufgrund der in der Literatur beschriebenen Diskrepanz zwischen Bereitschaft zum Artenschutz und Einstellung gegenüber der jeweiligen Art wurden in der ersten Teilstudie (Teilstudie A) zunächst Einstellungen bezüglich wahrgenommener Gefahr, Interesse und Schutz der Biene von Schülern und Studierenden sowie Imkern als Referenzgruppe erfasst. Hierbei konnte gezeigt werden, dass die wahrgenommene Gefahr in einem direkten Zusammenhang zur Einstellung gegenüber dem Schutz der Biene steht. Obwohl die Einstellung zu Bienen in allen befragten Gruppen durchschnittlich positiv war, wurden individuelle Erfahrungen und das Wissen über die Fähigkeit der Bienen zu stechen dennoch als Gründe für eine potentielle Angst erkannt.

Alle weiteren Teilstudien basierten auf der Durchführung eines speziell entwickelten Unterrichtmoduls zur Leistung und Bedeutung der Honigbiene. Insgesamt nahmen rund 350 Schüler an den schülerzentrierten Lernstationen teil, die zwei methodischen Ansätzen folgten. Sowohl die Begegnung mit lebenden Bienen an einem Bienenstock als auch das Arbeiten mit einem Online-Bienenstock trugen zu einer anhaltenden Änderung der Wahrnehmung bei. Neben der Steigerung von Interesse und Reduktion der wahrgenommenen Gefahr konnte die Einstellung in Hinblick auf den Schutz der Bienen

gefördert werden (Teilstudie B). Darüber hinaus trugen auch beide Ansätze zum Erwerb eines anhaltenden umweltrelevanten Wissens über Bienen bei (Teilstudie C).

Während vor allem Jugendliche mit weniger positiven Umwelteinstellungen mithilfe des Online-Bienenstocks in Bezug auf Wissenserwerb adressiert werden konnten, hatte die wahrgenommene Gefahr überraschenderweise keinerlei Auswirkung auf den kognitiven Erfolg der Schüler.

Beim Arbeiten mit den lebenden Bienen zeigten die Schüler insgesamt positivere Lernemotionen als beim Arbeiten mit dem Computer. Trotz dieser Tatsache und weiteren Vorteilen des Einsatzes von Originalobjekten, die der Literatur entnommen werden können, stellt der Einsatz digitaler Medien in diesem Kontext eine wertvolle Alternative dar. Durch das Erfassen des Computerselbstkonzeptes in der letzten Teilstudie (Teilstudie D) konnte darüber hinaus festgestellt werden, dass die Attribution der eigenen Fähigkeiten im Hinblick auf den Umgang digitaler Medien von Schüler/innen in der Sekundarstufe ausreichend positiv ist, sodass der Einsatz von eLearning keine Hindernisse beim erfolgreichen Lernen darstellt.

3 AUSFÜHRLICHE ZUSAMMENFASSUNG

3.1 Einleitung

Bienen, Schmetterlinge, Käfer und weitere Organismen besitzen eine außerordentliche Schlüsselposition in vielen terrestrischen Ökosystemen. Durch ihre Bestäubungsleistung ermöglichen sie die sexuelle Vermehrung von Blütenpflanzen. Eine Vielzahl an Kultur- und Wildpflanzen ist abhängig von tierischen Bestäubern, was sie wiederum essentiell für Mensch und Natur macht (Buchmann & Nabhan, 1996; Kearns, Inouye, & Waser, 1998). Ein Verlust von Bestäubern würde das Gleichgewicht in Ökosystemen auf komplexe Art und Weise beeinflussen und zur Verarmung genetischer Vielfalt führen (Díaz, Fargione, Chapin, & Tilman, 2006). Im Rahmen des weltweiten Biodiversitätsverlusts wurde in den letzten Jahrzehnten auch ein starker Rückgang von Bestäubern beobachtet (Potts et al., 2010). Insbesondere haben Bienen in diesem Zusammenhang für öffentliche Aufmerksamkeit gesorgt (Byrne & Fitzpatrick, 2009; Neumann & Carreck, 2010). Um dem beobachteten Rückgang entgegenzuwirken, haben Wissenschaft und Politik bereits reagiert: Es wurden Forschungen und Studien über Trends, Ausmaß und Triebkräfte durchgeführt, jedoch werden diese kontrovers diskutiert. Aktuell wird davon ausgegangen, dass nicht einzelne Faktoren wie Verlust von Habitaten, Einsatz von Pestiziden oder Klimawandel Einfluss auf den Verlust von Bestäubern haben, sondern vielmehr die Mischung der sich gegenseitig verstärkenden Stressfaktoren auf die Arten wirken (Goulson, Nicholls, Botias, & Rotheray, 2015). Trotz kontroverser Meinungen ist man sich über die Notwendigkeit des aktiven Handelns und die Sensibilisierung für den Bestäuberschutz auf globaler und lokaler Ebene einig (Byrne & Fitzpatrick, 2009). Nur so kann die Aufrechterhaltung elementarer Ökosystemfunktionen, Biodiversität und damit eine vielfältige Nahrungsgrundlage vieler Tierarten, inklusive des Menschen, sichergestellt werden. Ein Beispiel für das globale Handeln ist der Zusammenschluss mehrerer Organisationen auf internationaler Ebene, der *Intergovernmental Platform on Biodiversity and Ecosystem Services* (IPBES), der sich mit der nachhaltigen Nutzung auseinandersetzt und sich dem Erhalt biologischer Vielfalt widmet. Die erste thematische Festsetzung des IPBES beschäftigte sich mit dem Schutz von Bestäubern, wobei Handlungsoptionen für die Politik erarbeitet wurden (Díaz, Demissew, Joly, Lonsdale, & Larigauderie, 2015).

Auf lokaler Ebene müssen wiederum andere Instrumente für die Sensibilisierung der Öffentlichkeit für den Bestäuberschutz eingesetzt werden, wie z.B. Umweltbildung (Abrol, 2011; Kearns et al., 1998). Übergeordnetes Ziel von Umweltbildung ist die Vermittlung eines verantwortungsbewussten Umgangs mit der Natur und ihren Ressourcen (Potter, 2009). Es ist notwendig, dass Bildungsmaßnahmen u.a. Wissen, Einstellungen, Motivation und

Engagement gezielt fördern (UNESCO, 1976). Der Schwerpunkt der vorliegenden Arbeit liegt auf der Evaluation einer Bildungsmaßnahme zum Bestäuberschutz am Beispiel der Honigbiene. Besonderes Augenmerk wird dabei auf spezifische Aspekte der Einstellung gegenüber der Biene und ihren Schutz gelegt sowie auf den Erwerb umweltrelevanten Wissens.

3.2 Theoretischer Hintergrund

3.2.1 Einstellungen gegenüber Bienen als Bestäuber

Erfolgreiche Umweltbildung kann durch negative Emotionen wie Angst oder Ekel gehemmt werden (Bixler & Floyd, 1999). Jedoch werden gerade Insekten und andere Wirbellosen häufig mit Abneigung, Aversion und Angst assoziiert (Davey, 1994; Kellert, 1993).

Diese bestehenden negativen Einstellungen gegenüber bestimmter Tiergruppen oder einzelner Arten werden durch verschiedene Faktoren beeinflusst, denn Einstellungen sind definiert als komplexe Konstrukte, bestehend aus kognitiven, affektiven und konativen Elementen, die untereinander stark interagieren (Eagly & Chaiken, 1993). Während auf kognitiver Ebene negative Wahrnehmungen oftmals durch Mythen oder Aberglauben (Prokop, Fančovičová, & Kubiatko, 2009) sowie andere kulturelle oder individuelle Faktoren (Herzog & Burghardt, 1988; Serpell, 2004) beeinflusst werden, haben soziales Lernen (Olsson & Phelps, 2007) und persönliche Erfahrungen (Rachman, 1977) Wirkung auf affektiver Ebene, insbesondere auf die Entwicklung von Ängsten. Mehrere Studien bestätigten die Beliebtheit von Säugetieren und anderen Wirbeltieren im Vergleich zu Wirbellosen (Arrindell, 2000; Bjerke, Ødegårdstuen, & Kaltenborn, 1998). Obwohl Insekten mit praktischem Wert im Allgemeinen positiver wahrgenommen werden (Kellert, 1993), gehören Bienen zu den mit Angst assoziierten Tieren (Arrindell, 2000; Gerdes, Uhl, & Alpers, 2009).

Die Bereitschaft, sich für den Schutz einer Art einzusetzen, kann durch die Einstellung gegenüber der jeweiligen Art beeinflusst werden. So wurde z.B. gezeigt, dass Menschen weniger bereit waren, Geld für den Erhalt von Artenvielfalt aufzuwenden, als es sich um unbeliebte Tiere handelte (Martín-López, Montes, & Benayas, 2007). Dabei können kognitive Faktoren wie Tradition oder Glauben (Ceriaco, Marques, Madeira, Vila-Vicosa, & Mendes, 2011) sowie affektive Faktoren wie Angst und Ekel (Prokop & Fančovičová, 2010, 2013) einen negativen Einfluss auf die Bereitschaft haben. Inwiefern die Bereitschaft Bienen zu schützen und die Angst vor ihnen in einem Zusammenhang stehen, wurde bislang noch nicht untersucht.

3.2.2 Umweltwissen und -einstellungen

Die Tatsache, dass Wissen, Einstellungen und Handlungen in einer direkten Beziehung stehen, ist bekannt, die spezifischen Zusammenhänge dagegen sind komplex. Ursprüngliche Theorien gingen davon aus, dass die drei Determinanten in einer linearen Beziehung zueinander stehen, die von Wissenserwerb über Einstellungsänderungen zu einem beabsichtigten Verhalten führt (Fishbein & Ajzen, 1975). Heutige Theorien und Modelle sind feiner differenziert und beinhalten mehrere Dimensionen und Einflussvariablen. Im Rahmen der Umweltpsychologie und -bildung wurde ein Umweltkompetenzmodell erarbeitet (Kaiser, Roczen, & Bogner, 2008; Roczen, Kaiser, Bogner, & Wilson, 2014). Wissen wird dabei zunächst in verschiedene Dimensionen eingeteilt: Umweltsystemwissen, Handlungswissen und relatives Effektivitätswissen (Frick, Kaiser, & Wilson, 2004). Der Erwerb von Wissen aller drei Dimensionen ist notwendig, da der Erwerb einer Wissensart alleine nicht unbedingt zu einem umweltbewussten Verhalten führt. Im gleichen Modell stellen Umwelteinstellungen (Roczen et al., 2014) sowie Naturverbundenheit (Kaiser et al., 2008) starke Einflussfaktoren auf die Intention umweltbewussten Handelns dar. Gemäß des Modells wurde bereits in empirischen Studien gezeigt, dass Umwelteinstellungen Einfluss auf das Wissen haben sowie umgekehrt und dass dieses Konstrukt darüber hinaus durch Umweltbildung beeinflusst werden kann (z.B. Fremerey & Bogner, 2015; Liefländer & Bogner, 2016). Das Modell verdeutlicht, dass umweltbildende Maßnahmen neben dem Lernen auf kognitiver Ebene (Erwerb von Umweltweltwissen) auch einen Fokus auf affektive Elemente (Förderung von Einstellungen und Werten) haben sollte.

3.2.3 Ausgewählte methodische Ansätze in der Umweltbildung

Inzwischen gibt es eine Vielzahl an empirischen Studien, die die Wirkung von Unterricht und Umweltbildungsprogrammen auf Wissen, Einstellungen und weitere Variablen ermittelten. Umweltrelevantes Wissen bezüglich verschiedener Themen (z.B. Pflanzen, Wasser, etc.) konnte sowohl durch längere Bildungsprogramme (Bogner, 1998; Liefländer, Bogner, Kibbe, & Kaiser, 2015) als auch durch Unterricht von wenigen Stunden (Fančovičová & Prokop, 2011; Sattler & Bogner, 2016) akquiriert werden. Die Förderung positiver Umwelteinstellungen bedarf wiederum längerer Interventionen (Bogner, 1998; Johnson & Manoli, 2010). Innerhalb der Bildungsmaßnahmen variierten die angewandten Methoden entsprechend der Themen und der Zielgruppe. So wurden u.a. positive Erfolge beim Einsatz von Lernstationen (z.B. Sattler & Bogner, 2016; Sellmann & Bogner, 2013), Exkursionen (z.B. Ballouard, Provost, Barré, & Bonnet, 2012; Randler, Ilg, & Kern, 2005) oder durch Besuche von Zoologischen Gärten oder Aquarien (Ballantyne, Packer, Hughes, & Dierking, 2007) erzielt. Zelezny (1999) ermittelte im Rahmen einer Meta-Studie, dass

umweltbewusstes Verhalten effektiver durch Interventionen im Klassenzimmer als durch alternative Ansätze, wie Exkursionen o.ä. beeinflusst werden kann. Jedoch war dabei die aktive Teilnahme der Schüler der Erfolgsfaktor, die eher im Klassenzimmer gegeben war. Im Gegensatz dazu stellten Duerden und Witt (2010) heraus, dass Umwelteinstellungen effektiver durch direkte Erfahrungen mit der Natur gefördert werden können, während der Erwerb von Wissen durch direkte und indirekte Erfahrungen gleichermaßen beeinflusst wird. Eine Kombination der Erfolgsfaktoren beider Studien wäre der Einsatz von Methoden, die sowohl eine aktive Teilnahme der Lernenden als auch die direkte Erfahrung mit Natur ermöglichen. Speziell im Bereich der Umweltbildung, die auf den Erhalt der Artenvielfalt abzielt, wäre somit die Begegnung mit lebenden Organismen in der Natur durch schülerzentrierte Methoden optimal.

In einem anderen Kontext konnte gezeigt werden, dass Unterricht mit lebenden Tieren, also eine direkte Erfahrung, positive Effekte auf Wissenserwerb (Hummel & Randler, 2012) und Emotionen hatte (Randler, Hummel, & Wüst-Ackermann, 2013). Jedoch konnten Schüler durch den Einsatz alternativer Unterrichtsmittel (z.B. Film) im direkten Vergleich mehr Wissen akquirieren (Hummel & Randler, 2010). Der Einsatz von Tieren im Klassenzimmer zeigte bei den Lernenden besonders Wirkung auf affektiver Ebene: Lernemotionen waren besonders positiv (Hummel & Randler, 2010) und Aversion, Angst und Ekel konnten reduziert werden (Bauhardt, 1990; Killermann, 1996; Randler, Hummel, & Prokop, 2012). Auch die Begegnung mit Tieren auf Freilandexkursionen oder in Zoologischen Gärten zeigte Wirkung, indem die Schüler nachher gegenüber dem Erhalt der Artenvielfalt positiver eingestellt waren (Ballantyne et al., 2007), sogar wenn es sich um unbeliebte Tiergruppen handelte (Ballouard et al., 2012).

Obwohl der Einsatz von lebenden Tieren optimal als Methode für umweltbildende Maßnahmen scheint, sind nicht immer passende Rahmenbedingungen gegeben. So kann, je nach Thema, das Wetter oder die Jahreszeit unpassend, die Tierart lokal nicht verfügbar oder die benötigte Zeit begrenzt sein. Im Fall von lebenden Bienen ist die Haltung und Pflege in der Schule schwierig, da oftmals der Platz im Schulgarten fehlt. Zudem setzt der Umgang mit Bienen eine gewisse Erfahrung und Expertise voraus. Beobachtungen aus der Nähe und Anfassen der Tiere sind bei großen Gruppen oder ganzen Schulklassen schwierig zu ermöglichen. In diesen Fällen ist die Auswahl einer alternativen Methode für das Erreichen gleicher oder ähnlicher Lernziele erforderlich.

Im Hinblick auf Umweltbildung wird der Einsatz von digitalen Medien in den letzten Jahren immer häufiger angewandt (Fauville, Lantz-Andersson, & Säljö, 2014). Vor allem im Bereich *Citizen Science* werden entsprechende Medien häufig eingesetzt, die somit eine Verbindung zwischen Bildung, Umwelt und Wissenschaft darstellen (Wals, Brody, Dillon, & Stevenson,

2014). ELearning als „Neueinsteiger“ in der Umweltbildung bietet Möglichkeiten des problemorientierten Lernens oder des handlungsorientieren Unterrichts (Fauville et al., 2014). Diverse Studien evaluierten bereits entwickelte Programme und Anwendungen wie virtuelle Labore, Spiele oder Simulationen hinsichtlich ihrer Effektivität v.a. auf kognitiver Ebene (z.B. Hickey, Ingram-Goble, & Jameson, 2009; Wrzesien & Alcañiz Raya, 2010). Jedoch fehlen weitere Studien über die Wirkung und Beeinflussung v.a. von affektiven Variablen mit Umweltrelevanz, wie z.B. Einstellungen oder Emotionen (Fauville et al., 2014).

Obwohl es bereits zahlreiche Forschungsarbeiten über die Entwicklung neuer Anwendungen und ihre Effektivität gibt, beschäftigen sich wenige Studien mit der Angepasstheit der Methode (Einsatz von digitalen Medien) an die Lebenswelt der Kinder und Jugendlichen. Das Computerselbstkonzept, das Wissen bzw. die Attribution eines Schülers im Hinblick auf die eigenen Fähigkeiten im Umgang mit dem Computer, ist in diesem Zusammenhang z.B. von zentraler Bedeutung, um einen effektiven Lernprozess sicherzustellen (Guay, Marsh, & Boivin, 2003).

3.3 Ziele und Fragestellungen der Teilarbeiten

Die vorliegende Arbeit widmet sich dem Bestäuberschutz und zielt darauf ab, im Rahmen eines exemplarischen Unterrichtmoduls für die Sekundarstufe die Wertschätzung der Honigbiene durch eine positive Wahrnehmung sowie die Steigerung von relevantem Umweltwissen zu fördern. Dabei werden zwei verschiedene methodische Ansätze hinsichtlich ihrer Effektivität evaluiert: Der Einsatz des Originalobjekts (lebende Bienen an einem Bienenstock) und das Arbeiten mit einer Internetplattform, die mit einem realen Bienenstock verbunden ist (siehe Abb.1).

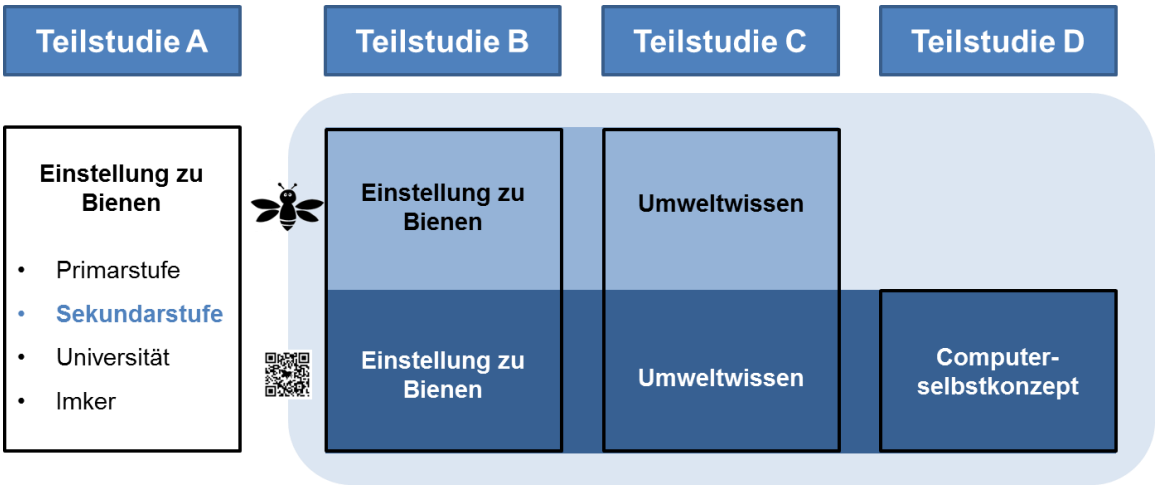

Abb.1 Übersicht über die Teilarbeiten der Gesamtstudie

Anmerkung: Die Biene symbolisiert den Umgang mit den lebenden Bienen, der QR-Code den Einsatz von eLearning

Teilstudie A: Einstellung zu Bienen

In der ersten Teilstudie soll zunächst die Wahrnehmung von Bienen mithilfe eines einfachen Instrumentes überprüft werden. Abgeleitet aus der Literatur, besteht eine Diskrepanz zwischen der Notwendigkeit des Schutzes der Bestäuber (Byrne & Fitzpatrick, 2009) und der oftmals negativen Wahrnehmung von Insekten im Allgemeinen (Kellert, 1993) und Hymenopteren im Besonderen (Arrindell, 2000; Gerdes et al., 2009). Deshalb liegt der Schwerpunkt dieser Arbeit auf der individuellen Einstellung bezüglich der wahrgenommenen Gefahr, Interesse und Schutz der Honigbiene. Es werden Schüler und Studenten unterschiedlicher Altersstufen und somit verschiedener Erfahrungsniveaus sowie Experten verglichen, um erfahrungsbedingte Unterschiede zu erfassen. Des Weiteren soll ermittelt werden, warum die Biene oftmals als gefährlich wahrgenommen wird und inwieweit der Schutzgedanke ausgeprägt ist. Es wird eine positivere Wahrnehmung im Hinblick auf Gefährlichkeit, Schutz und Interesse mit zunehmenden Alter und Expertise erwartet. Zudem wird vermutet, dass die Bereitschaft die Biene zu schützen von einer stark wahrgenommenen Gefahr und niedrigem Interesse beeinträchtigt wird.

Die konkreten Fragestellungen dieser Teilstudie lauten:

1. Ist ein angepasstes Semantisches Differential ein passendes Instrument, um individuelle Einstellung bezüglich wahrgenommener Gefahr, Interesse und Schutz der Biene zu erfassen?
2. Gibt es einen Zusammenhang zwischen der wahrgenommenen Gefahr, individuellem Interesse und der Bereitschaft die Biene zu schützen?
3. Wie ist die Einstellung zu Bienen von Schülern und Studenten verschiedener Altersgruppen sowie von Experten?
4. Welche individuellen Gründe existieren für die wahrgenommene Gefahr und den Schutz der Biene?

Teilstudie B: Positive Einstellung gegenüber Bienen verstärken

Im Rahmen des Biologieunterrichts sollen die in Teilstudie A ermittelten Einstellungen mithilfe eines Unterrichtsmoduls zur Bedeutung der Honigbiene als Bestäuber positiv verstärkt werden. Aufgrund der Verknüpfung zum bayerischen Lehrplan (StUK, 2001, 2007) wird ein angepasstes Unterrichtsmodul für die Sekundarstufe konzipiert. Lernen am Originalobjekt, z.B. mit lebenden Tieren, wurde vielfach angewandt und besonders im Hinblick auf die Förderung affektiver Lernziele bestätigt (Ballouard et al., 2012; Randler et al., 2012). Im Fall von lebenden Bienen ist der Einsatz im Biologieunterricht jedoch oftmals schwierig oder gar unmöglich. Der Besuch eines Bienenstocks am Schulgelände oder bei

einem Imker in der Nachbarschaft ist durchaus denkbar, allerdings nicht immer verfügbar. Um trotzdem die Vorteile einer originalen Begegnung, wie z.B. das Fördern von wissenschaftlichen Arbeitsweisen oder das Hervorrufen emotionaler Verbundenheit (Hummel & Randler, 2010) zu nutzen, kann im Unterricht die Internetplattform HOBOS (Honeybee Online Studies, http://www.hobos.de/) eingesetzt werden. Da HOBOS mit einem realen Bienenstock verbunden ist, haben Schüler die Möglichkeit Bienen via Live Streams zu beobachten sowie sich eingehend mit Charakteristika des Bienenstocks zu beschäftigen. Der Schwerpunkt dieser Teilstudie liegt darauf, zwei unterschiedliche methodische Ansätze, der Besuch eines Bienenstocks und das Arbeiten mit dem online-Bienenstock HOBOS, hinsichtlich affektiver Lernziele zu vergleichen. Ziel ist es, durch das Unterrichtsmodul das Interesse der Schüler für Bienen zu wecken, die wahrgenommene Gefahr zu reduzieren und die Bereitschaft die Biene zu schützen zu erhöhen. Es wird erwartet, dass beide methodischen Ansätze diese Ziele unterstützen, wobei die Primärerfahrung mit dem Originalobjekt am Bienenstock die wahrgenommene Gefahr stärker reduzieren sollte. Zusätzlich sollen die Lernemotionen der Schüler in beiden Ansätzen ermittelt und miteinander verglichen werden. Es wird erwartet, dass das Interesse und das Wohlbefinden der Schülergruppe, die den Bienenstock besucht, höher und die Langeweile niedriger ist als bei jener Schülergruppe, die mit HOBOS arbeitet.

Die konkreten Fragestellungen dieser Teilstudie lauten:

1. Kann durch eine dreistündige Intervention die Einstellung bezüglich wahrgenommener Gefahr, Interesse und Schutz der Biene positiv verstärkt werden?
2. Gibt es Unterschiede zwischen dem Lernen am Originalobjekt (Bienenstock) und dem Einsatz von eLearning (HOBOS) bezüglich Einstellung gegenüber Bienen und Lernemotionen?
3. Inwiefern gibt es einen Zusammenhang zwischen Lernemotionen und der Einstellung gegenüber Bienen?

Teilstudie C: Umweltrelevantes Wissen über Bienen fördern

Der Schwerpunkt der dritten Teilstudie liegt auf dem Erwerb umweltrelevanten Wissens über Bienen als Bestäuber. Dabei sollen, analog zu Teilstudie B, die beiden methodischen Ansätze des Unterrichtsmoduls auf ihre Effektivität untersucht werden. Neben der Evaluierung des kognitiven Lernerfolgs mithilfe eines geeigneten Wissensinstruments soll ermittelt werden, in welcher Beziehung das umweltrelevante Wissen über Bienen zu Umwelteinstellungen sowie zur individuellen Einstellung bezüglich wahrgenommener Gefahr und Schutz von Bienen steht. Erwartet werden bei beiden methodischen Ansätzen kurz- und langfristige Lernerfolge durch die Teilnahme am Unterrichtsmodul. Es wird zudem vermutet,

dass sowohl eine positive Umwelteinstellung als auch eine positive Einstellung gegenüber Bienen den Wissenserwerb begünstigen, negative Einstellungen wiederum das Gegenteil bewirken.

Die konkreten Fragestellungen der Teilstudie C lauten:

1. Nimmt das umweltrelevante Wissen über Bienen durch die Teilnahme am Unterrichtsmodul bei beiden methodischen Ansätzen (Originalobjekt, eLearning) kurz- und langfristig zu?
2. Inwiefern gibt es einen Zusammenhang zwischen dem umweltrelevanten Wissen über Bienen und Umwelteinstellungen bzw. Einstellungen gegenüber Bienen bezüglich wahrgenommener Gefahr und Schutz?

Teilstudie D: Das Computerselbstkonzept von Jugendlichen

Digitale Medien werden immer häufiger im Biologieunterricht und in der Umweltbildung eingesetzt. Sie treffen den Nerv der Zeit und eröffnen zahlreiche neue Möglichkeiten des Lernens (Fauville et al., 2014). Das Computerselbstkonzept, das Wissen bzw. die Attribution eines Schülers im Hinblick auf die eigenen Fähigkeiten im Umgang mit dem Computer, sollte möglichst hoch sein, um einen effektiven Lernprozess zu gewährleisten (Guay et al., 2003). Selbstkonzepte im Bezug zu digitalen Medien variieren hinsichtlich Alter und Geschlecht (Comber, Colley, Hargreaves, & Dorn, 1997; Sáinz & Eccles, 2012). Ziel dieser Teilstudie ist es deshalb, ein geeignetes Instrument zur Messung des Computerselbstkonzeptes zu validieren und jenes Selbstkonzept in der Zielgruppe zu überprüfen, um einen Prädiktor für den erfolgreichen Einsatz von eLearning im Sekundarstufenunterricht zu erhalten.

Die konkreten Fragestellungen dieser Teilstudie lauten:

1. Wie ist das Computerselbstkonzept von Schülern der achten Jahrgangsstufe im Vergleich zu anderen Altersgruppen?
2. Gibt es Geschlechtsunterschiede im Hinblick auf das Computerselbstkonzept?

3.4 Methoden

3.4.1 Teilnehmer und Studiendesign

Aufgrund der unterschiedlichen Ziele und Fragestellungen der einzelnen Teilarbeiten variierten die Studienteilnehmer sowie das Design innerhalb der Gesamtstudie.

Für **Teilarbeit A** wurden Daten von Schülern und Studenten als Novizen und Imkern als Experten erhoben. Da die Themen *Bienen* und *Bestäubung* mehrfach im bayerischen Lehrplan verankert sind (StUK, 2001, 2007), wurden Schüler zweier Altersgruppen befragt: 78 Primarstufenschüler der vierten und fünften Jahrgangsstufe (Alter, $M \pm SD = 10{,}4 \pm 0{,}7$; 56,4% weiblich) sowie 321 Sekundarstufenschüler der siebten und achten Jahrgangsstufe (Alter, $M \pm SD = 13{,}6 \pm 0{,}7$; 43,3% weiblich). Zudem nahmen 100 Studenten nicht-biologischer Fächer der Universität Bayreuth an der Studie teil (Alter, $M \pm SD = 22{,}8 \pm 2{,}4$; 56,0% weiblich). Als Experten standen 153 lokale Imker zur Verfügung, die den Imkertag der Bayerischen Landesanstalt für Weinbau und Gartenbau besuchten (Alter, $M \pm SD = 57{,}8 \pm 13{,}5$; 32,4% weiblich).

Die empirische Studie, im Rahmen von **Teilarbeit B und C,** wurde mit 400 Schülern der siebten und achten Jahrgangsstufe durchgeführt. Insgesamt nahmen 354 Schüler aus 14 Klassen bayerischer Realschulen und Gymnasien im Sommerhalbjahr 2014 an dem Unterrichtsmodul teil, 46 Schüler (Alter, $M \pm SD = 13{,}4 \pm 0{,}6$; 52,2% weiblich) in zwei Klassen eines Gymnasiums dienten ohne Teilnahme als Kontrollgruppe. Das Unterrichtsmodul wurde mithilfe zweier methodischer Ansätze durchgeführt: 162 Schüler (Alter, $M \pm SD = 12{,}7 \pm 1{,}1$; 51,2% weiblich) bearbeiteten das Modul *Let it Bee* mit lebenden Bienen an einem Bienenstock, 192 Schüler (Alter, $M \pm SD = 13{,}9 \pm 0{,}6$; 39,6% weiblich) bearbeiteten das Modul *HOBOS - Das fliegende Klassenzimmer* mithilfe von eLearning. Die Datenerhebung erfolgte im Rahmen eines quasi-experimentellen Designs mittels Fragebögen (*paper-and-pencil*). Ein bis zwei Wochen vor der Teilnahme am Modul wurde der erste Fragebogen an den Schulen ausgefüllt (T0), zwei weitere Fragebögen folgten direkt im Anschluss an das Unterrichtsmodul (T1) und sechs bis neun Wochen später (T2). Die Kontrollgruppe ohne die Teilnahme an einem Modul erhielt die Fragebögen nur zu zwei Testzeitpunkten im Abstand von ca. zwei Wochen. Um die Fragebögen einander zuordnen zu können, wurden sie mit einem vertraulichen Code aus Geschlecht, Geburtsmonat und -jahr sowie Anfangsbuchstaben der Mutter und Hausnummer versehen.

Für **Teilarbeit D** wurden Daten von insgesamt 521 Schülern und Studenten verschiedener Fachrichtungen verwendet: 192 Schüler der achten Jahrgangsstufe, analog zu Teilstudien B und C (Alter, $M \pm SD = 13{,}8 \pm 0{,}6$; 39,6% weiblich), 214 Schüler der elften Jahrgangsstufe

(Alter, $M \pm SD = 17{,}1 \pm 0{,}7$; 48,6% weiblich) und 115 Studenten verschiedener Fachrichtungen der Universität Bayreuth (Alter, $M \pm SD = 21{,}1 \pm 2{,}4$; 58,3% weiblich).

3.4.2 Erhebungsinstrumente und Datenauswertung

Die Genehmigung der Datenerhebung an den Schulen wurde im April 2014 durch das Bayerische Staatsministerium für Bildung und Kultus, Wissenschaft und Kunst genehmigt (III.9-5 O 5106/100/11). Die Fragebögen wurden der befragten Altersgruppe, den Fragestellungen und der entsprechenden Stichprobe angepasst. In den Teilarbeiten wurden nur ausgewählte Instrumente untersucht, die in längere Fragebögen eingebettet waren.

Alle statistischen Auswertungen der Daten wurden mit SPSS (22.0) ausgeführt, sofern nicht anders angegeben. Da die Werte einiger Variablen nicht einer Normalverteilung folgten, wurden nicht-parametrische Tests zur Hypothesenüberprüfung verwendet.

Zur Erfassung der individuellen Einstellung bezüglich wahrgenommener Gefahr, Interesse und Schutz der Biene, wurde in **Teilstudie A** ein angepasstes Semantisches Differential eingesetzt. Ein Semantisches Differential erfasst die Meinung oder Einstellung einer Person bezüglich eines bestimmten Objekts. Dabei werden den Befragten bipolare Adjektive angeboten, zwischen denen sie sich positionieren sollen (Hill, Osgood, Suci, & Tannenbaum, 1958). Die in der Studie eingesetzten zehn Wortpaare wurden von Drissner und Kollegen (2013) adaptiert (z.B. unbedeutend/notwendig, unheimlich/harmlos, langweilig/spannend) und neunstufig skaliert. Leitsatz für die Positionierung zwischen den Adjektiven war „Bienen finde ich…“. Um die Wortpaare eindeutig zu den Faktoren *Gefährlichkeit*, *Schutz* und *Interesse* zuordnen zu können, wurde eine explorative Faktorenanalyse (Hauptachsenanalyse mit schiefwinkliger Rotation, *Oblimin*) durchgeführt. Nach Ausschluss zweier Items aufgrund unzureichender Güte dienten die berechneten Faktorenwerte als Grundlage für eine bivariate Korrelation und für die Ermittlung von Altersgruppenunterschieden.

Darüber hinaus wurden zwei offene Fragen gestellt, die sich auf die Positionierung im Semantischen Differential bezogen und Aufschluss über die Gründe für eine wahrgenommene Gefahr und den Schutz der Biene geben sollte. Die Befragten wurden aufgefordert zu erläutern, warum sie die Biene (1) eher gefährlich oder ungefährlich und (2) eher unwichtig oder schützenswert finden. Die Antworten wurden mithilfe einer qualitativen Inhaltsanalyse nach Mayring (2010) ausgewertet. Dabei wurden die Expertenantworten verwendet, um induktiv Kategorien zu bilden, zu denen wiederum deduktiv die Novizenantworten zugeordnet wurden. Im Anschluss wurden Antworthäufigkeiten, also

relative Häufigkeiten der Nennung einer Kategorie, zwischen den einzelnen Gruppen verglichen.

Nachdem das Semantische Differential zur Erfassung der Einstellung bezüglich wahrgenommener Gefahr, Interesse und Schutz der Biene im Rahmen von Teilstudie A auf seine Anwendbarkeit überprüft wurde, konnte es in **Teilstudie B** eingesetzt werden, um zu ermitteln, ob eine positive Einstellung durch die Intervention gefördert werden konnte. Dazu wurde das Instrument bei den Teilnehmern des Unterrichtsmoduls zu allen drei Testzeitpunkten eingesetzt und der Median der einzelnen Faktoren zwischen den drei Testzeitpunkten verglichen. Anschließend wurden Unterschiede in Bezug auf kurz- und langfristige Veränderungen der Einstellung betrachtet. Des Weiteren wurden unmittelbar nach der Intervention (T1) in einem fünfstufigen Likert-Format die situationsbezogenen Lernemotionen *Wohlbefinden*, *Interesse* und *Langeweile* mit jeweils drei Items gemessen (nach Randler et al., 2011). Pro Subskala wurden Mittelwerte gebildet, die als Grundlage für die Korrelation mit der Einstellung und für den Vergleich der beiden methodischen Ansätze dienten.

In **Teilstudie C** lag der Schwerpunkt auf dem Erwerb umweltrelevanten Wissens über Bienen durch das speziell entwickelte Unterrichtsmodul. Insgesamt mussten die Teilnehmer jeweils 27 Multiple-Choice Fragen zu drei Testzeitpunkten beantworten, die auf den Inhalt des Moduls abgestimmt waren. Da jeweils nur eine der vier Antwortmöglichkeiten korrekt war, wurden die Antworten in 1 (richtig) und 0 (falsch) für die statistische Auswertung kodiert. Für die Analyse des Umweltwissens wurden aufgrund des Inhalts des Moduls nur elf entsprechend relevante Wissensfragen ausgewählt und mithilfe des Rasch-Modells auf ihre Qualität überprüft. Im Vergleich zur sonst angewandten klassischen Testtheorie folgt das Rasch-Modell einer probabilistischen Theorie, der eine simultane Schätzung der Personenfähigkeit und der Itemschwierigkeit zugrunde liegt (Bond & Fox, 2007). Die Raschskalierung wurde mithilfe des Programms ACER Conquest 3 ausgeführt. Nach der Qualitätsüberprüfung wurden Summenwerte derjenigen Schüler berechnet, die ein vollständig ausgefülltes Fragebogenset (T0, T1, T2) aufwiesen. So konnten 115 Teilnehmer des *Let it Bee*-Programms, 134 des *HOBOS - Das fliegende Klassenzimmer*-Programms und 46 Schüler ohne Programmteilnahme (Kontrolle) in weiteren statistischen Auswertungen berücksichtigt und deren Wissenszuwachs bestimmt werden.

In einem zweiten Schritt wurde überprüft, ob ein Zusammenhang zwischen Wissen und Einstellung zu Bienen bzw. allgemeiner Umwelteinstellung besteht. Dazu wurde neben dem Semantischen Differential (siehe Teilarbeiten A und B), die 2-MEV-Skala (*Two Major Environmental Values*, Kibbe, Bogner, & Kaiser, 2014) zur Auswertung verwendet. Dem 2-MEV-Modell liegen die beiden unabhängigen Dimensionen Naturschutz- (*preservation*) und

Natur(aus)nutzungs-Präferenz (*utilisation*) zugrunde. Um die Gesamtlänge des Fragebogens zu reduzieren, wurden nur die elf höchstladenden Items nach Kibbe, Bogner und Kaiser (2014) aus der ursprünglichen 20-Item-Skala verwendet. Die Mittelwerte der jeweiligen Einstellungsvariablen wurden mit den Wissensniveaus korreliert. Zusätzlich wurden die Stichproben beider methodischer Ansätze bezüglich aller Einstellungsvariablen jeweils in zwei Gruppen mittels Mediansplit aufgeteilt (*Low-/High-Scorer*). Im Anschluss wurden die gebildeten Gruppen wiederum bezüglich Umweltwissen innerhalb der Testzeitpunkte miteinander verglichen.

In **Teilstudie D** musste zunächst ein geeignetes Instrument zur Messung des Computerselbstkonzeptes validiert werden. Dazu konnte eine bestehende Skala mit elf Items (Schwanzer, 2002) auf ein einfaktorielles Instrument aus sechs Items mit hinreichend hoher Reliabilität (Cronbach's Alpha = 0,84) und Validität reduziert werden. Zu diesem Zweck wurde neben einer explorativen Faktorenanalyse (Hauptachsenanalyse, *Varimax*), Trennschärfe und Skalenhomogenität ermittelt, Außenkriterien (z.B. Häufigkeit der Computernutzung) abgefragt und mit den Skalenwerten korreliert sowie die Reliabilität bestimmt. Anschließend wurden Mittelwerte gebildet und die Computerselbstkonzeptwerte der drei Altersstufen und der Geschlechter verglichen.

3.4.3 Unterrichtsmodul

Im Hinblick auf den theoretischen Hintergrund und die Zielsetzung dieser Arbeit wurde ein Unterrichtsmodul entwickelt, das den beschriebenen Anforderungen sowie dem bayerischen Lehrplan gerecht wird. Ziel des Lernmoduls war es, das Bewusstsein für den Bestäuberschutz am Beispiel der Honigbiene zu fördern und eine Wertschätzung gegenüber der Biene als faszinierenden und zentralen Organismus für Mensch und Natur zu entwickeln. Dabei wurde die Honigbiene (*Apis mellifera*) als exemplarischer Organismus ausgewählt, da das Thema Bestäubung und Bienen explizit in den bayerischen Lehrplänen der Realschulen und Gymnasien zu finden ist (StUK, 2001, 2007). In Anlehnung an die Lehrpläne wurde das Unterrichtsmodul daher für die siebte Jahrgangstufe Realschule und die achte Jahrgangsstufe Gymnasium konzipiert.

Im Rahmen einer dreistündigen Unterrichtseinheit (135 Minuten) wurde ein schülerzentriertes Modul, basierend auf Lernstationen, mit zwei unterschiedlichen methodischen Ansätzen entwickelt. Bei vergleichbarem Inhalt hatten die Schüler im Lernprogramm ***Let it Bee*** einige Aufgaben, die beim Besuch eines Bienenstocks zu lösen waren, den Schülern des Programms ***HOBOS - Das fliegende Klassenzimmer*** stand wiederum der Online-Bienenstock der Internetplattform HOBOS für die Aufgaben zur

Verfügung. In beiden Programmen arbeiteten die Schüler an den Lernstationen in selbstgewählten Zweier- oder Dreiergruppen. Jedem Schüler wurde nach einer kurzen Einführung ein Arbeitsheft ausgehändigt, das neben allgemeinen Erklärungen alle Aufgaben und Arbeitsaufträge enthielt (siehe externer Anhang). Die Schüler konnten in Eigenverantwortung und in ihrem eigenen Lerntempo die Stationen selbstständig bearbeiten und ihre Lösungen bei Anfrage mit jeweiligen Musterlösungen am Lehrerpult vergleichen. Dabei spielte die Reihenfolge der Bearbeitung keine Rolle.

Das Programm *Let it Bee* gliederte sich in zwei Teile: Die vier Lernstationen im Klassenzimmer und der Besuch eines Bienenstocks, der von der *Umweltstation Weismain* auf dem Schulgelände aufgestellt wurde. Der Besuch des Bienenstocks verlief zeitgleich zur Bearbeitung der Lernstationen und enthielt Aufträge, die dem Inhalt der Stationen angepasst waren bzw. diesen ergänzten. Das Programm *HOBOS - Das fliegende Klassenzimmer* beinhaltete ebenfalls vier Lernstationen, die jeweils in zwei Unterstationen strukturiert waren. Eine der beiden Unterstationen enthielt jeweils ausschließlich *hands-on* Materialien, die andere zusätzliche eLearning-Aufgaben, die mit der Internetseite HOBOS gelöst werden konnten.

Lernstationen. Die ersten beiden Lernstationen beschäftigen sich mit grundlegenden Informationen und Abläufen im Bienenstock, damit Schüler diese verstehen und eine Offenheit für die Biene als faszinierenden Organismus entwickeln. **Station 1** gab einen Überblick über die Wachsproduktion und den Wabenbau der Honigbienen. Das Wachs, das als Baustoff für die Wabenzellen eines Bienenstockes hergestellt wird, wird eigens von den Bienen produziert und anschließend verarbeitet. Die Waben sind in einer bestimmten regelmäßigen geometrischen Form angelegt, deren charakteristische sechseckige Wabenzellen durch Erhitzen des Wachses durch die Bienen aus ursprünglich errichteten röhrenförmigen Zellen entstehen. Der Vorteil dieses Gebildes ist ein maximal hohes Raumvolumen bei minimalem Einsatz von Baustoff. Dieses Naturphänomen wird wiederum als Vorbild in technischen Anwendungen und der Architektur verwendet (Bionik). Der Inhalt von **Station 2** befasste sich mit weiteren Abläufen im Bienenstock, nämlich der Kommunikation und der Thermoregulation des Bienenvolkes. Grundsätzlich sollte spielerisch das Prinzip vermittelt werden, dass Information (z.B. über die Lage einer Nahrungsquelle) als Bewegung kodiert werden kann. Bei den Bienen wird diese Information durch sog. Tänze kommuniziert. Darüber hinaus war die Thermoregulation des Bienenstocks Inhalt dieser Station (bzw. bei *Let it Bee* Teil des Bienenstockbesuchs). Durch Erzeugung von Wärme bzw. Hervorrufen von Verdunstungskälte halten die Bienen als gesamtes Volk die Stocktemperatur relativ konstant, um Kälte- bzw. Hitzeschäden zu vermeiden. Obwohl Bienen als Insekten wechselwarme Tiere sind, kann das Bienenvolk als gleichwarmer Superorganismus betrachtet werden.

Die beiden weiteren Stationen beschäftigen sich mit der ökonomischen und ökologischen Leistung der Bienen sowie mit ihrer Gefährdung durch anthropogene Einflüsse. Die Schüler sollten die Notwendigkeit erkennen, die Biene und ihren Lebensraum zu schützen. In **Station 3** wurden zunächst alle Produkte der Honigbiene betrachtet. Während z.B. Honig und Wachs offensichtliche Erzeugnisse sind, wird die Bedeutung der Bienen als Bestäuber vieler Nutz- und Wildpflanzenarten oftmals unterschätzt. Zu diesem Zweck wurden erst alle Produkte dem Nutzen nach kategorisiert, die Arbeit der Bienen für ein Glas Honig berechnet und sich dann der Bestäubung gewidmet. Die meisten Blütenpflanzen weltweit werden von Insekten bestäubt, wovon die Honigbiene einen großen Teil der Leistung übernimmt. Deshalb gilt die Biene als drittwichtigstes Nutztier nach Rind und Schwein (Tautz, 2007). Der Inhalt der **Station 4** befasste sich mit dem Bienensterben. Es wurde Wert darauf gelegt, sowohl natürliche Sterbeursachen wie Altersschwäche oder Parasitenbefall zu beleuchten als auch Sterbeursachen, die durch anthropogene Einflüsse begünstigt werden. Darunter fallen z.B. der Einsatz von einigen Pflanzenschutzmitteln oder die Veränderung natürlicher Lebensräume durch Urbanisierung oder Anbau von Monokulturen. In einem zweiten Schritt standen Interessenskonflikte zwischen Landwirtschaft, Politik und Gesellschaft im Vordergrund, wobei anschließend mögliche Handlungsoptionen für die einzelnen Interessensgemeinschaften erarbeitet wurden.

Bienenstock. Der Besuch des Bienenstocks beim Programm *Let it Bee* wurde in Kleingruppen von acht bis zehn Schülern durchgeführt. Die standardisierte Führung wurde von einer erfahrenen Imkerin und Mitarbeiterin der Umweltstation Weismain geleitet. Sie wurde vorher über den Inhalt der Führung instruiert. In entsprechender Schutzausrüstung beobachteten die Schüler zunächst den Bienenstock, bevor er durch die Imkerin geöffnet und erklärt wurde. Mithilfe eines Protokolls hatten die Schüler z.B. die Aufgabe die Temperatur im Inneren, an der Außenseite und der Luft zu erfassen sowie Beobachtungen über Ein- und Ausflugrate der Bienen zu notieren. Darüber hinaus erhielt jeder Schüler mindestens eine Interviewfrage, die er der Imkerin bei der Führung stellen sollte. Im Anschluss trug die Gruppe alle Antworten, z.B. über Thermoregulation oder natürliche Sterbeursachen, gemeinsam zusammen und ergänzte die Informationen im Protokoll.

eLearning mit HOBOS. HOBOS, kurz für *Honeybee Online Studies*, ist eine interaktive Lehr- und Lernplattform, die mit einem Bienenstock in Würzburg verbunden ist. Verschiedene technische Ausstattungen wie Kameras, Messgeräte, Waage etc. erlauben einen tieferen Einblick in den Bienenstock. Es können entweder Verhaltensbeobachtungen in Echtzeit über Webcams durchgeführt oder verschiedene ermittelte Daten über längere Zeiträume abgerufen werden. Im Programm *HOBOS - Das fliegende Klassenzimmer* wurden zum Teil bereits bestehende Lernmodule, zum Teil eigens entwickelte Arbeitsaufträge von den Schülern bearbeitet. Zum Beispiel bekamen die Schüler die Aufgabe, den Stockeingang

via Live Stream zu beobachten und anhand der ausfliegenden Bienen einen Durchschnitt an möglichen bestäubten Blüten zu berechnen. Bevor die Schüler die Lernstationen bearbeiteten, erhielten sie Zeit, sich mithilfe einer gedruckten Anleitung mit der Internetseite vertraut zu machen. Die eLearning-Aufgaben waren in die jeweiligen Stationen eingebettet und es stand den Schülern neben zusätzlichem *hands-on* Material pro Station mindestens ein Computer oder Laptop zur Verfügung.

3.5 Ergebnisse und Diskussion

Der Fokus der vorliegenden Gesamtarbeit liegt auf der Effektivität von Unterricht hinsichtlich der Einstellung gegenüber dem Bestäuberschutz am Beispiel der Honigbiene. Dabei wurden die Einstellung gegenüber Bienen sowie der Erwerb umweltrelevanten Wissens über Bienen näher betrachtet. Teilstudie A diente der Erfassung des Status Quo bezüglich der Einstellung gegenüber Bienen, was wiederum die Grundlage des Unterrichtsmoduls darstellte. In Teilstudien B und C wurde dann die Effektivität der Intervention hinsichtlich Veränderung der Wahrnehmung und Wissenserwerb evaluiert. Aufgrund der Verwendung von eLearning in einem umweltbildenden Kontext, lag ein Schwerpunkt darauf, das Computerselbstkonzept der Jugendlichen zu erheben und zu evaluieren. Diese Überprüfung ermöglichte den Einsatz der eLearning-Plattform HOBOS. Inhaltlich hat diese Teilstudie deshalb keinen direkten Bezug zum Thema Bestäuberschutz, validiert jedoch die eingesetzte Methode. Dementsprechend werden die Ergebnisse der Teilstudie D außerhalb des Gesamtkontextes der Arbeit betrachtet und diskutiert.

3.5.1 Teilstudie A - Einstellungen gegenüber Bienen

Zur Erfassung der Einstellung gegenüber Bienen wurde ein Semantisches Differential eingesetzt. Die statistischen Analysen bestätigten die Anwendbarkeit des Instruments zur Erfassung von Einstellungen bezüglich wahrgenommener Gefahr, Interesse und Schutz der Biene. Acht von zehn Wortpaaren konnten auf drei Faktoren reduziert werden, die hinreichende Reliabilität aufwiesen: *Gefährlichkeit* (2 Items; Cronbach's α = 0,82), *Interesse* (3 Items; α = 0,87) und *Schutz & Nützlichkeit* (3 Items; α = 0,82). Die beiden Wortpaare schlecht/gut und eklig/niedlich konnten keinem Faktor eindeutig zugewiesen werden und wurden nicht in die folgenden Auswertungen einbezogen.

Korrelationen der Faktorenwerte ergaben, dass die drei Faktoren *Gefährlichkeit*, *Interesse* und *Schutz & Nützlichkeit* miteinander in Beziehung stehen. Während die Bereitschaft die Biene zu schützen positiv mit dem Interesse an Bienen korreliert, steht sie in einem

negativen Zusammenhang mit der wahrgenommenen Gefahr. Die wahrgenommene Gefahr korreliert indes negativ mit dem Interesse an Bienen (siehe Abb. 2).

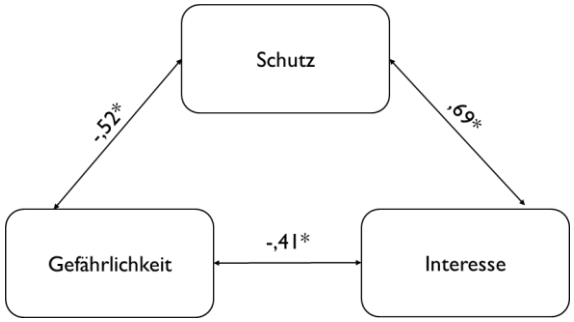

Abb. 2. Zusammenhang zwischen den Faktoren *Gefährlichkeit*, *Interesse* und *Schutz & Nützlichkeit*

Diese Ergebnisse bestätigen die Annahme, dass negative Einstellungen bzw. Emotionen wie Angst oder Ekel die Bereitschaft ein Tier zu schützen mindern können (Knight, 2008; Prokop & Fančovičová, 2013). Darüber hinaus kann die Hypothese unterstützt werden, dass das Steigern von Interesse einen positiven Beitrag zur Einstellung gegenüber Arten- bzw. Umweltschutz leisten kann (Lindemann-Matthies, 2005). Deshalb sollte in umweltbildenden Initiativen sowohl eine mögliche negative Wahrnehmung von Tieren als auch das Interesse der Lernenden berücksichtigt werden.

Die Auswertung des Semantischen Differentials in den verschiedenen Stichproben (Schüler der Primar- und Sekundarstufe, Studenten und Imker) hat ergeben, dass alle Gruppen im Durchschnitt bereits eine positive Einstellung gegenüber Bienen besitzen. Das Ergebnis ist überraschend, da frühere Studien gezeigt haben, dass Bienen und andere Insekten im Vergleich zu anderen Arten eher negativ wahrgenommen werden (Arrindell, 2000; Gerdes et al., 2009). Ursachen könnten kulturelle Gründe sein, da die Studien in anderen Regionen der Welt erhoben wurden. Eine weitere Erklärung wäre, dass sich bereits Auswirkungen verschiedener öffentlichkeitswirksamer Initiativen und Kampagnen in solchen Ergebnissen wiederspiegeln. Wie erwartet, heben sich die Imker in allen drei abgefragten Aspekten positiv von den Schülern und Studenten ab, was als Validitätskriterium der verwendeten Skala gesehen werden kann. Darüber hinaus kann die Einstellung der Imker auch als Referenz für die Möglichkeit zur Steigerung der Einstellung anderer Gruppen betrachtet werden. Die zwei Schüler- und die Studentengruppe unterscheiden sich hinsichtlich wahrgenommener Gefahr und Schutz der Biene nicht voneinander, jedoch in Bezug auf ihr Interesse an Bienen. Die teilnehmenden Primarstufenschüler haben höheres Interesse an Bienen, was nicht überrascht, da jüngere Schüler bekanntermaßen ein größeres Interesse an biologischen

Themen besitzen (Prokop, Prokop, & Tunnicliffe, 2007) und sich der Natur stärker verbunden fühlen (Liefländer, Fröhlich, Bogner, & Schultz, 2013).

Wenn man die Antworten auf die offenen Fragen betrachtet, werden die Gründe für die Wahrnehmung der Biene deutlich. Auf die Frage, warum die Biene eher gefährlich bzw. nicht gefährlich wahrgenommen werde, berichteten viele der Befragten von einer bedingten Gefährlichkeit. Zum Beispiel wurde erklärt, dass Bienen an sich harmlos seien, außer sie würden provoziert werden. Dabei wurde die Gefahr meist mit dem Bienenstachel oder dem Stich assoziiert, was hinsichtlich anderer Tierarten bereits bekannt ist (vgl. Breuer, Schlegel, Kauf, & Rupf, 2015; Gerdes et al., 2009; Münstedt & Mühlhans, 2013). Berücksichtigt man, dass die Imker seltener mithilfe des Bienenstichs argumentierten, ist anzunehmen, dass Erfahrungen und Vorwissen bei dieser negativen Wahrnehmung eine Rolle spielen (vgl. Rachman, 1977) und die Novizen wahrscheinlich wenige, jedoch schmerzhafte Erfahrungen mit Stichen gemacht haben. Weitere genannte Gründe für die Gefährlichkeit von Bienen konnten kategorisiert werden in das *Wesen der Biene* und den *Umgang mit Bienen*. Je erfahrener die Befragten, desto häufiger bezogen sie sich auf charakteristische Wesenszüge der Biene (z.B. „Bienen verteidigen ihr Volk“) und desto seltener auf den menschlichen Umgang mit ihr (z.B. „Wenn man die Biene nicht reizt, tut sie einem nichts“).

Obwohl die Bereitschaft die Biene zu schützen bereits gut ausgeprägt ist, spielen die Gründe für den Schutz eine wichtige und interessante Rolle. Besonders jüngere Schüler nennen in diesem Zusammenhang eher Bienenprodukte wie Honig oder Bienenwachs anstelle der Bestäubungsleistung. Ältere Schüler sowie Studenten und Imker argumentieren für den Schutz mit der Bestäubungsleistung der Bienen und der damit verbundenen Bedeutung für Mensch und Natur. Es ist bekannt, dass während der Schulzeit die Einstellung gegenüber Tieren mit nützlichem Wert (z.B. Haus- und Nutztiere) abnimmt, wohingegen jene mit ökologischem Wert (z.B. Bestäuber) zunimmt (Kellert, 1985). Besonders die Studenten und Imker nennen die Bestäubung und deren ökologischen Wert als Argument für den Schutz. Das ist nicht verwunderlich, da anzunehmen ist, dass diese Gruppen eher von medienpräsenten Initiativen angesprochen werden. Auffällig war jedoch, dass jeder fünfte Sekundarstufenschüler vom Aussterben der Menschheit berichtete, im Falle des Verschwindens der Biene. Diese Aussage bezieht sich auf ein vermeintliches Zitat von Albert Einstein: „Wenn die Biene von der Erde verschwindet, dann hat der Mensch nur noch vier Jahre zu leben“ (Tautz, 2007, S. 272). Während dieses Zitat häufig für den Bestäuberschutz eingesetzt wird, wird es sowohl aufgrund seiner wissenschaftlichen Ungültigkeit als auch seines falschen Ursprungs kontrovers diskutiert (Mingo, 2013; Tautz, 2007). Die Tatsache, dass es v.a. von Sekundarstufenschülern als Argumentationsgrundlage genutzt wurde, lässt darauf schließen, dass hauptsächlich vorangegangene Unterrichtsinhalte durch andere Lehrkräfte Aussagen diesbezüglich beinhalteten. Es sollte in zukünftigen Programmen

darauf geachtet werden, dass wissenschaftlich korrekte Darstellungen vermittelt werden, um Fehlvorstellungen oder übertriebene Vorstellungen der Schüler zu vermeiden.

3.5.2 Teilstudie B - Förderung positiver Einstellungen gegenüber Bienen

Nachdem die Einstellungen gegenüber Bienen in Hinblick auf wahrgenommene Gefahr, Interesse und Schutz von verschiedenen Altersgruppen im Rahmen von Teilstudie A ermittelt wurden, wurde die Sekundarstufe für Folgestudien herausgegriffen. Durch ein für die Zielgruppe abgestimmtes Unterrichtsmodul zur Bedeutung der Honigbienen für Mensch und Natur konnten positive Einstellungen hinsichtlich der drei Aspekte gefördert werden. Das Interesse und die Einstellung gegenüber dem Schutz der Biene konnten kurz- und langfristig gesteigert, die wahrgenommene Gefahr wiederum im gleichen Maße reduziert werden. Ähnliche Effekte bei umweltbildenden Maßnahmen bezüglich unbeliebter Tiere sind in der Literatur bekannt (Ballouard et al., 2012).

Teilstudie B konnte die positive Wirkung des Einsatzes des Originalobjekts im Unterricht auf affektiver Ebene bestätigen (Killermann, 1996; Randler et al., 2012). Darüber hinaus konnte in diesem Kontext ebenso eine positive Wirkung des Einsatzes des online-Bienenstocks HOBOS auf die Einstellung gegenüber Bienen erzielt werden. Beide methodischen Zugänge förderten gleichermaßen das Interesse und die Einstellung zum Schutz von Bienen. Vergleicht man die beiden Ansätze hinsichtlich der wahrgenommenen Gefahr, konnte festgestellt werden, dass die Begegnung mit den lebenden Bienen einen stärkeren kurzfristigen Effekt aufwies, langfristig aber keine Unterschiede auftraten. Ein direkter Vergleich beider Methoden ist in der Literatur nicht bekannt. Jedoch gibt es ähnliche Studien, in denen sich die Begegnung lebender Tiere positiv auf die Reduktion von Angst und Ekel im Vergleich zu alternativen Unterrichtsmitteln (Bilder, Modelle) auswirkt (Killermann, 1996). Das überaus positive Resultat des eLearnings in Teilstudie B kann darüber hinaus die bereits bekannten Vorteile seines Einsatzes in der Umweltbildung ergänzen (Fauville et al., 2014).

Obwohl keine nennenswerten Unterschiede zwischen der Wirkung beider Zugänge in Bezug auf die Einstellung festgestellt werden konnten, unterscheiden sie sich dennoch hinsichtlich der hervorgerufenen Lernemotionen. Schüler, die beim Unterrichtsmodul den Bienenstock besuchten, berichteten von einem höherem Wohlbefinden und weniger Langeweile im direkten Vergleich zur eLearning-Gruppe. Dies bestätigt frühere Studien, die feststellten, dass das Wohlbefinden im Schulkontext bei der Begegnung mit lebenden Tieren hoch und die Langeweile gering ist (Hummel & Randler, 2010; Randler et al., 2005). Das situative Interesse war bei Schülern beider Gruppen vergleichbar hoch, was im Kontrast zu o.g.

Studien steht. Ursachen dafür können das Thema *Bienen* an sich sein, aber auch die wahrgenommene Selbstbestimmtheit, besonders bei Bearbeitung der eLearning-Aufgaben, die als Vermittler positiver Emotionen bekannt ist (Pekrun, Goetz, Titz, & Perry, 2002).

Durch Korrelation der Lernemotionen *Wohlbefinden*, *Interesse* und *Langeweile* mit den gemessenen Aspekten zur Einstellung gegenüber Bienen (*Gefährlichkeit*, *Interesse*, *Schutz & Nützlichkeit*) konnte ein Zusammenhang der beiden Konstrukte festgestellt werden. Ähnlich wie in der Arbeit von Fröhlich, Sellmann, und Bogner (2013) konnte ein Zusammenhang zwischen positiver Lernemotion und der Intention zu positivem Umweltverhalten festgestellt werden, insofern man die Einstellung gegenüber dem Schutz der Biene als vergleichbaren Aspekt betrachtet. Darüber hinaus wurden Zusammenhänge zwischen positiven Lernemotionen und wahrgenommener Gefahr in Form von negativen Korrelationen bzw. Interesse an Bienen (positive Korrelationen) gefunden. Dies lässt darauf schließen, dass v.a. im Hinblick auf die Förderung umweltbewussten Verhaltens die Aktivierung positiver Emotionen im Bildungskontext von Nöten ist.

3.5.3 Teilstudie C - Förderung umweltrelevanten Wissens über Bienen

Teilstudie C beschäftigte sich mit dem Erwerb von Umweltwissen durch die Teilnahme am entwickelten Unterrichtsmodul, da Umweltwissen als ein grundlegender Prädiktor umweltbewussten Verhaltens gilt.

Zunächst wurde die Qualität des Instruments zur Erfassung umweltrelevanten Wissens über Bienen überprüft. Aus den ursprünglichen 27 Wissensitems wurden elf relevante Multiple-Choice-Fragen ausgewählt, die direkten Bezug zu den Stationen des Unterrichtsmoduls mit ökologischem Kontext haben. Die ausgewählten Items wurden anschließend mithilfe des Raschmodells skaliert und deren Kennwerte bestimmt. Zur Überprüfung der internen Konsistenz wurden für alle drei Testzeitpunkte gewichtete Abweichungsquadrate, t-Werte sowie die Trennschärfe betrachtet. Alle bestimmten Werte lagen dabei in dem in der Literatur angegeben akzeptablen Bereich (Adams & Wu, 2002). Darüber hinaus wurde die Reliabilität der Skala bestimmt. Während die Item-Reliabilität (T0/T1/T2 = 0,97/0,92/0.94) hoch war, schwankte die Personen-Reliabilität zwischen den einzelnen Testzeitpunkten um einen mäßigen Wert (0,46/0,56/0,61). Da sich die drei Stichproben der unterschiedlich methodischen Ansätze und der Kontrollgruppe im Wissenslevel unterschieden, führte dies womöglich zur leichten Veränderung der Reliabilität. Da die Skala ansonsten hinreichend gute Kennwerte aufwies, wurde sie zur Erfassung des Wissens in der Teilstudie eingesetzt. Lerneffekte durch den Fragebogen an sich konnten durch die Kontrollgruppe ausgeschlossen werden. Nachdem jedoch ein signifikanter Unterschied zwischen dem

Wissenslevel der beiden Hauptstichproben während allen drei Testzeitpunkten festgestellt wurde, wurde davon abgesehen, die beiden Gruppen bezüglich ihres Wissens statistisch miteinander zu vergleichen. So werden sie im Folgenden als getrennte Studien parallel behandelt und einander gegenübergestellt.

Die Teilnahme am Unterrichtsmodul förderte umweltrelevantes Wissen über Bienen, unabhängig des methodischen Zugangs (Bienenstock und eLearning). Wie erwartet, konnte ein Wissenszuwachs sowohl kurzfristig direkt nach Teilnahme am Unterricht als auch langfristig, sechs bis neun Wochen später, festgestellt werden (im umweltbildenden Kontext, vgl. Fančovičová & Prokop, 2011; Sattler & Bogner, 2016). Vor dem Hintergrund, dass Umweltbildung nicht nur bei Ausflügen in den Wald oder in den Zoologischen Garten passieren kann, sondern in den Schulalltag integriert werden sollte, sind beide Zugänge des Unterrichtsmoduls positive Beispiele für den Einsatz in der Schule.

Neben den Vorteilen hinsichtlich affektiven Lernens ist die positive Wirkung von lebenden Tieren auf kognitiver Ebene ebenfalls bekannt, weshalb sie mittlerweile immer häufiger im Unterricht eingesetzt werden (Hummel & Randler, 2012). Im Hinblick auf einen umweltbildenden Kontext gibt es jedoch wenig vergleichbare Arbeiten, da bisherige Studien die Natur eher als Ganzes (Bogner, 1998) oder nur weniger spezifische Taxa miteinbezogen haben (Sattler & Bogner, 2016). Der Einsatz von eLearning (im Speziellen HOBOS) stellt eine gute Alternative zum Erwerb von Umweltwissen dar, zumal im Schulkontext nicht immer ein nahegelegener Bienenstock für den Unterricht zur Verfügung steht oder Wetter, Zeit bzw. andere organisatorische Gegebenheiten unpassend sind. Der Einsatz von eLearning in der Umweltbildung ist wenig bekannt (Fauville et al., 2014), jedoch gibt es erste Studien, die bereits kognitive Erfolge erzielten (Petersson, Lantz-Andersson, & Saljö, 2013). Teilstudie C widmet sich dagegen dem Erwerb eines spezifizierten Wissens mit Umweltbezug mithilfe von eLearning. Generell sollte jedoch angemerkt werden, dass die Effektivität nicht einem bestimmten methodischen Zugang zuzuordnen ist, da beiden Ansätzen die zusätzlich ausgearbeiteten Lernstationen mit *hands-on* Materialien zugrunde lagen. Die positive Wirkung von Lernstationen in der Umweltbildung ist indes bekannt (Sattler & Bogner, 2016; Sellmann & Bogner, 2013).

In weiteren Analysen wurde der Zusammenhang des Umweltwissens mit Umwelteinstellungen bzw. der Einstellung bezüglich wahrgenommener Gefahr und Schutz der Biene untersucht. Entgegen der Erwartung, positive Umwelteinstellungen würden den Erwerb umweltrelevanten Wissens begünstigen (Fremerey & Bogner, 2015; Liefländer & Bogner, 2016), konnte bei der HOBOS-Gruppe festgestellt werden, dass Schüler mit niedrigerer Umweltschutz-Präferenz einen Wissensunterschied kurzfristig aufholten. Vor dem Unterricht und einige Wochen später zeigten die Schüler mit höherer Schutz-Präferenz

jedoch mehr Wissen als diejenigen mit niedrigerer. Das gleiche Muster konnte in dieser Gruppe bei Schülern mit einer höheren Umwelt(aus)nutz-Präferenz erkannt werden. In der Bienenstock-Gruppe stand die Einstellung im Hinblick auf Umweltschutz in keinem Zusammenhang, während eine negative Umwelt(aus)nutz-Präferenz gleichmäßig mit höherem Wissen einherging (vgl. Liefländer & Bogner, 2016). Das Ergebnis lässt vermuten, dass der Einsatz von eLearning vor allem diejenigen Schüler mit niedrigeren Schutz- und höheren (Aus)nutz-Präferenzen angesprochen hat, sodass sie die Wissenslücke kurzfristig schließen konnten. Im Hinblick auf den zugrunde liegenden Zusammenhang sollten jedoch weitere Arbeiten durchgeführt werden, um diese Vermutung zu bestätigen, zumal in der vorliegenden Studie Deckeneffekte (Wissen und MEV) sowie die Erscheinung einer sozialen Erwünschtheit nicht auszuschließen sind.

Wie vermutet, korrelierte in beiden Gruppen das umweltrelevante Wissen über Bienen mit der Einstellung zum Schutz der Biene. Schüler mit einer sehr positiven Einstellung hatten vor dem Unterricht bereits mehr Wissen und behielten das neu erworbene Wissen auch länger. Diejenigen mit einer niedrigeren Einstellung schlossen die Wissenslücke wiederum nur kurzfristig. Bei diesem Ergebnis sollte jedoch darauf hingewiesen werden, dass sich die Einstellung gegenüber Bienen durch die Teilnahme an der Intervention geändert hatte (Teilstudie B).

Wider Erwartens, dass erfolgreiche Umweltbildung durch negative Emotionen wie Angst oder Ekel gehindert wird (Bixler & Floyd, 1999), wurde in beiden Gruppen zu keinem Testzeitpunkt ein Zusammenhang zwischen dem Wissen und der wahrgenommenen Gefahr nachgewiesen. Im Vergleich zu vorangegangenen Studien (z.B. Hummel & Randler, 2010) werden Bienen weniger als eklig empfunden (Randler et al., 2013) als die dort verwendeten Tiere (Regenwurm, Kellerassel, Schnecke). Weitere Vergleichsstudien, die sich ausschließlich mit dem Umgang mit Angst hervorrufender Tiere im Unterricht beschäftigen, sind v.a. im umweltbildenden Bereich empfehlenswert.

3.5.4 Teilstudie D - Computerselbstkonzept

Aufgrund des eLearning-Anteils im methodischen Ansatz *HOBOS - Das fliegende Klassenzimmer*, sollte in Teilstudie D das Computerselbstkonzept der Jugendlichen bestimmt werden, da insbesondere schulische Selbstkonzepte den Lernprozess von Schülern beeinflussen können (Guay et al., 2003).

Zu diesem Zweck wurde eine aus der Literatur übernommene Kurzskala (Schwanzer, 2002) angepasst und als einfaktorielles Instrument mit einer hohen Reliabilität und internen Konsistenz validiert. Durch die Faktorenanalyse konnte die Skala von elf auf sechs Items mit

ausreichend hohen Kennwerten (Faktorenladungen, Trennschärfe und Cronbach's Alpha wenn Item gelöscht) reduziert werden. Neben einer zufriedenstellenden Skalenhomogenität wies die Skala eine gute Reliabilität auf, die über Alter und Geschlecht stabil blieb. Durch Korrelation mit den Außenkriterien konnte zudem eine kriteriumsgeleitete Validität sichergestellt werden.

Die Auswertung des Computerselbstkonzeptes der einzelnen Altersgruppen zeigte, dass die Jugendlichen der achten Jahrgangsstufe im Mittel ein signifikant höheres Computerselbstkonzept als die älteren Jahrgänge aufwiesen. Der beobachtete abfallende Trend deckt sich mit der Literatur (Comber et al., 1997). Es kann davon ausgegangen werden, dass die Jugendlichen der Sekundarstufe (insbesondere der achten Jahrgangsstufe) bereits ein ausreichend hohes Computerselbstkonzept besitzen, sodass der Lernprozess dadurch nicht beeinträchtigt wird.

Vergleicht man das Computerselbstkonzept zwischen den Geschlechtern, wurde ein signifikanter Unterschied zwischen männlichen und weiblichen Teilnehmern deutlich, der jedoch mit zunehmendem Alter abnahm. Männliche Teilnehmer hatten dabei ein höheres Selbstkonzept als weibliche, jedoch näherten sich die Geschlechter beidseitig an. Obwohl Geschlechtsunterschiede im Hinblick auf das Computerselbstkonzept bereits bekannt sind, ist die beobachtete Annäherung neu, da bisher von einer Vergrößerung des Unterschiedes ausgegangen wurde (Sáinz & Eccles, 2012). Wenn im Unterricht eLearning zum Einsatz kommt, sollte auf das Computerselbstkonzept geachtet werden, insbesondere auf das der Schülerinnen, sodass erfolgreiches Lernen nicht durch die Methode beeinträchtigt wird.

3.6 Schlussfolgerung und Ausblick für Unterricht und Forschung

Vor dem Hintergrund des anhaltenden Biodiversitätsverlusts (Díaz et al., 2006) und der damit verbundenen Erforderlichkeit, das Bewusstsein für den Schutz von Bestäubern zu stärken (Byrne & Fitzpatrick, 2009), konnte eine insgesamt sehr positive Wahrnehmung von Bienen festgestellt werden. Die vorliegende Studie setzte dabei den Schwerpunkt auf den Schulkontext, wobei neben Schülern der Primar- und Sekundarstufe auch Universitätsstudenten miteinbezogen wurden. In zukünftiger Forschung könnten weitere Gesellschaftsgruppen befragt werden. Die Erfassung der Einstellung von Personen der Landwirtschaft und der Öffentlichkeit wäre dabei von Interesse, ebenso wie die Einstellung zu weiteren Bestäubern und kontrovers wahrgenommenen Arten. Zu diesem Zweck kann das Semantische Differential als schnelles und einfaches Instrument genutzt werden, jedoch wäre eine Bestätigung der Zuverlässigkeit in anderen Kontexten ratsam.

Umweltbildung ist auf lokaler Ebene ein Instrument für die Schaffung eines Bewusstseins für den Bestäuberschutz bzw. der Erhaltung der Natur im Allgemeinen. Lehrer und Mitwirkende von pädagogischen Einrichtungen sollten sich der Einstellungen, die Lernende mitbringen, bewusst sein, um Lernprogramme adressatengerecht und effektiv zu gestalten. Im Fall der Bienen konnte gezeigt werden, dass die Einstellung gegenüber dem Schutz der Biene in einem negativen Zusammenhang zur wahrgenommenen Gefahr und einem positiven Zusammenhang zum Interesse steht. Deshalb sollte bei Bildungsmaßnahmen in diesem Kontext insbesondere darauf geachtet werden, dass die wahrgenommene Gefahr reduziert und das Interesse an der Biene gesteigert wird, um die Schutzwilligkeit zu stärken.

Es wurde deutlich, warum Bienen oftmals als gefährlich eingestuft werden. Vor allem der Stachel der Biene und das Wissen, dass das Tier in Gefahrensituationen stechen kann, liegen der wahrgenommenen Gefahr zugrunde. Nicht festgestellt wurde dabei jedoch, inwiefern die Befragten in der Lage waren, zwischen Bienen und ähnlich aussehenden Insekten (z.B. Wespen, Hornissen) zu differenzieren. Diese Tatsache sollte in zukünftigen Forschungen berücksichtigt werden. Nichtsdestotrotz sollte in allen diesbezüglichen Bildungsprogrammen darauf geachtet werden, charakteristische Wesenszüge der Biene zu erklären und die Artenkenntnis zu schulen.

Obwohl Schüler und Studenten aller Altersklassen bereits vor einer Intervention die Notwendigkeit sehen die Biene zu schützen, unterscheiden sie sich dennoch bezüglich ihrer Gründe dafür. Je älter die Lernenden, desto stärker argumentieren sie aus einer ökologischen Sichtweise, also mit der Bestäubungsleistung der Biene und deren Bedeutung für Mensch und Natur. Jüngere Schüler benötigen noch Hilfestellungen beim Erkennen ökologischer Zusammenhänge. Auch wenn das vermeintliche Zitat Albert Einsteins über das Aussterben der Menschheit bei Verschwinden der Biene die Bereitschaft die Biene zu schützen erhöht, ist es dennoch fachlich inkorrekt. Anstatt das Zitat in Öffentlichkeitsarbeit oder Bildungsprogrammen als Druckmittel zum Umweltschutz zu verwenden, könnte es z.B. bewusst eingesetzt werden, um es zu falsifizieren und ökologische Zusammenhänge deutlich zu machen.

Mithilfe eines sorgfältig geplanten Unterrichtmoduls konnte gezeigt werden, dass o.g. Einstellungsaspekte gefördert werden können: Die wahrgenommene Gefahr wurde langfristig reduziert, Interesse an Bienen gesteigert und letztlich auch die Bereitschaft die Biene zu schützen erhöht. Der Fokus des Unterrichtsmoduls lag v.a. darauf, die Schüler von der Biene und ihrem Zusammenleben im Volk zu faszinieren, um Interesse zu wecken. Durch die Beobachtung von Bienen, das Arbeiten mit einem Bienenstock und erarbeitetes Wissen sollte die Wahrnehmung einer (bedingten) Gefahr hinsichtlich der Biene reduziert werden. Wie erwartet, förderte der affektive Ansatz, in dem Schüler lebenden Tieren

begegneten, den Abbau dieser negativen Emotion. Jedoch konnte auch mithilfe eines eLearning-Ansatzes diese negative Wahrnehmung gleichermaßen langfristig reduziert werden. Durch zusätzliche Information über die Leistung, Bedeutung und Gefährdung der Bienen konnten durch das Unterrichtsmodul mit beiden Zugängen die Bereitschaft Bienen zu schützen erhöht und somit ein Beitrag zum Bestäuberschutz geleistet werden.

Umweltwissen in seinen unterschiedlichen Dimensionen gilt als Grundlage für umweltbewusstes Handeln (Kaiser et al., 2008). Deshalb ist wichtig, dass neben der Förderung von Einstellungen ebenso Wert auf den Erwerb umweltrelevanten Wissens gelegt wird. Sowohl der Umgang mit lebenden Bienen im Unterricht als auch der Einsatz von eLearning konnten jenes Wissen fördern. Dabei lernten alle Schüler im Mittel dazu, egal welche Umwelteinstellung oder Einstellung gegenüber Bienen sie besaßen. Allerdings konnten Schüler, die mit dem Online-Bienenstock arbeiteten und weniger positive Umwelteinstellungen zeigten, einen Wissensvorsprung kurzfristig aufholen. Dies lässt darauf schließen, dass Schüler mit weniger positiven Einstellungen im Unterricht mit umweltbildendem Kontext mithilfe eines alternativen modernen Zugangs erreicht werden können. Aufgrund der Gesamtlänge der eingesetzten Fragebögen wurde darauf verzichtet, zwischen verschiedenen Dimensionen des Umweltwissens (Umweltsystemwissen, Handlungswissen, relatives Effektivitätswissen) zu differenzieren. Für zukünftige Arbeiten wäre es interessant, ähnliche methodische Ansätze zu diesem Thema hinsichtlich des Erwerbs differenzierten Umweltwissens zu evaluieren.

Obwohl der Einsatz von lebenden Tieren im Unterricht bzw. direkte Erfahrungen mit der Natur in umweltbildenden Maßnahmen bevorzugt werden sollten, ist dies in der Schulpraxis nicht immer möglich. Oftmals bietet sich nicht genügend Zeit, lebende Tiere sind nicht verfügbar oder schwierig im Klassenzimmer zu halten oder Wetter bzw. Jahreszeit sind unpassend. Der Einsatz von eLearning im Unterricht bietet dann eine wertvolle Alternative. Im Fall von HOBOS konnten sowohl umweltrelevantes Wissen erworben als auch positive Einstellungen gegenüber Bienen gefördert werden. Darüber hinaus konnten Schüler adressiert werden, die weniger positive Umwelteinstellungen aufwiesen. Da die Forschung über den Einsatz von eLearning in der Umweltbildung noch relativ jung ist (Fauville et al., 2014), ist es spannend und von hoher didaktischer Relevanz, weitere innovative eLearning-Anwendungen zu entwickeln, die Vor- und Nachteile zu ermitteln und diese zu veröffentlichen.

4 LITERATURVERZEICHNIS DER ZUSAMMENFASSUNG

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5 TEILARBEITEN

5.1 Publikationsliste

A Schönfelder, M.L. & Bogner, F.X. (2016)
Individual perception of bees: Between perceived danger and willingness to protect
PLOS ONE
(submitted, Manuscript ID PONE-D-16-10213R1)

B Schönfelder, M.L. & Bogner, F.X. (2016)
How to sustainably increase students‘ willingness to protect pollinators
Environmental Education Research
(submitted, Manuscript ID CEER-2016-0143)

C Schönfelder, M.L. & Bogner, F.X. (2016)
Two ways of acquiring environmental knowledge: By encountering living animals at a beehive and by observing bees via digital tools
International Journal of Science Education
(submitted, Manuscript ID TSED-2016-0312-A)

D Langheinrich, J., Schönfelder, M., & Bogner, F.X. (2015)
Measuring the computer-related self-concept
Journal of Educational Computing Research
doi: 10.1177/0735633115621066
(published)

5.2 Darstellung des Eigenanteils

Die Wortpaare des Semantischen Differentials in Teilstudie A wurden der Literatur entnommen und gemäß der Themenstellung von mir angepasst. Die Durchführung der Befragung, statistische Auswertung und Interpretation der Daten erfolgte durch mich.

Teilarbeiten B und C basieren auf einer Interventionsstudie mit empirischer Begleitung. Das Unterrichtsmodul wurde durch mich konzipiert und zusammengestellt. Dabei wurden sowohl Materialien selbst entworfen und entwickelt als auch auf bestehende Materialien (z.B. Texte und eLearning-Aufgaben) zurückgegriffen. Datenerhebung, statistische Analyse sowie Interpretation erfolgte durch mich.

Teilarbeiten A, B und C wurden von mir als Erstautorin eigenständig konzipiert, verfasst und in Zusammenarbeit mit meinem Mitautoren überarbeitet.

In Kooperation mit J. Langheinrich wurde in Teilarbeit D die verwendete Skala der Literatur entnommen und angepasst. Datenerhebung erfolgte zu gleichen Teilen durch J. Langheinrich und mich. Nach gemeinsamer Konzeption der Teilarbeit erfolgte die Auswertung und Interpretation der Daten durch J. Langheinrich in stetigem Austausch und Diskussion mit mir. J. Langheinrich verfasste Teilarbeit D als Erstautorin, Textergänzungen und Überarbeitung erfolgten durch mich und den Drittautor.

5.3 Teilarbeit A

Schönfelder, M.L. & Bogner, F.X. (2016)

Individual perception of bees: Between perceived danger and willingness to protect

PLOS ONE
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Individual perception of bees:

Between perceived danger and willingness to protect

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Abstract

The current loss of biodiversity has found its way into the media. Especially the loss of bees as pollinators has recently received much attention aiming to increase public awareness about the consequence of pollinator loss and strategies for protection. However, pollinating insects like bees often prompt considerable anxiety. Negative emotions such as fear and disgust often lead to lack of support for conservation and appropriate initiatives for protection. Our study monitored perceptions of bees in the contexts of conservation and danger bees possibly represent by applying a semantic differential using contrasting adjectives under the heading "I think bees are…". Additionally, open questions were applied to examine individual perceptions of danger and conservation of bees. Respondents were students from primary school, secondary school and university. We compared these novices (n = 499) to experts (beekeepers, n = 153). An exploratory factor analysis of the semantic differential responses yielded three major oblique factors: *Interest*, *Danger* and *Conservation & Usefulness*. The inter-correlations of these factors were significant. Although all subgroups showed an overall high willingness to protect bees, the perception of danger scored medium. The individual experience of bee stings was the most prevalent reason for expressing fear. Educational programs focusing on pollinator conservation may reduce the perceived danger through removing misinformation, and supporting interest in the species. Based on the overall positive attitude toward bees, we suggest introducing bees (e.g. *Apis mellifera*) as a flagship species for pollinator conservation.

Introduction

Pollination animals are key players in most terrestrial ecosystems, providing an essential ecological service which affects human life directly and indirectly [1,2]. Especially wild and domesticated bees are the primary pollinators of wild plants and agricultural crops. Through their ecological and economic value they hold an exceptional position within global ecosystems [2,3]. Among the generally detected loss of biodiversity [4] there is increasingly strong evidence for a decline in pollinators. This decline constitutes a potential threat to the vital ecological services, and could lead to a lasting negative effect on wild plant diversity, crop production and food security [3]. A variety of possible causes of this documented decline have attracted growing attention in recent decades by the scientific community and general public. A number of studies observed different factors which may be driving the detected loss. Habitat loss, parasites, disease as well as pesticides are the reported major stressors [5]. It should be underlined that in the majority of cases these factors do not act in isolation. Rather the interaction between these factors leads to harm, and this interaction seems to vary in different parts of the world [5]. Striving for a well-balanced healthy planet, awareness of pollinator conservation is needed at the local and global levels [6]. In recent years, various actions, campaigns and programs all over the world have been implemented to raise public awareness of the significance of pollinator conservation [1,7]. In the case of bees, the phenomenon of Colony Collapse Disorder, the unexpected loss of honeybee colonies, has attracted great attention among researchers, politics and the public in recent years [6,8]. One fundamental tool to locally counteract the current trend in biodiversity loss is environmental education [5,9], aiming to foster awareness of the conservation of biodiversity.

Insects and other invertebrates are often associated with negative emotions such as dislike, fear and aversion [10–12]. Attitudes may be described as a complex construct, consisting of cognitive (e.g. knowledge, ideas, thoughts), affective (e.g. emotions, feelings)

and conative (e.g. intended behavior) components which strongly influence each other [13]. Negative attitudes toward animals are assumed to be due to a biological predisposition to be prepared for potentially dangerous species [14] in order to defend oneself against predators, or avoid diseases and infections [15,16]. Focusing on the cognitive component, negative perceptions of animals are often accompanied by myths and superstitions [17] as well as by other cultural and/or individual factors [18,19]. Thus, potential alternative conceptions or misinformation, aligned with personal experience, media or formal interventions can influence attitudes [20]. In comparison, fear and disgust as parts of the affective component are based on social learning (instruction and observation) [21] and personal experiences (conditioning) [22,23]. Especially emotional responses toward animals are well documented in the scientific literature (e.g. 24–26). Previous studies about attitudes toward animals often refer to nine fundamental attitudinal 'types': aesthetic, dominionistic, ecologistic, humanistic, moralistic, naturalistic, negativistic, scientistic, and utilistic [27]. These types are influenced by diverse personal variables, such as gender or age [28,29]. For instance, the attitudes of 6 to 9 year-old children toward animals seem to be dependent on affective and emotional influences (e.g. high utilitarian, dominionistic and moralistic scale results) while for 10 to 13 year olds cognitive components (e.g. factual knowledge) seem to be prevalent. 13 to 16 year old students' attitudes are characterized by an increase in ethical concerns and ecological appreciation [27]. Further studies examining the likeability of different animal species found gender, age and educational level to be predictive for individual preferences [30]. Several studies confirm that vertebrates, especially mammals, are preferred over invertebrates (e.g. [31,32]. Although the fear of wasps and bees seems more intense [31,33], insects with a practical value (e.g. bees) are perceived more positively [11].

As shown by the association of environmental attitudes with pro-animal attitudes [34], the likeability of a species also affects conservation concern [35,36]: people are less willing to protect biodiversity when unpopular species are involved [37]. Additionally, Knight [38]

pointed out that the support of species protection is significantly related to attitude types, for instance, aesthetic, moralistic as well as negativistic (e.g. fear). More specific investigations showed that fear and disgust [12,39] but also beliefs in superstitions and myths [40] compromise a person's willingness to protect species.

Raising awareness about the importance of animal conservation and at the same time fostering pro-environmental behavior is a central issue of educational settings [9,41]. Education should focus on attitudes toward animals [34], as negative emotions could hinder successful learning [42]. Knowledge about peoples' existing attitudes is essential when educational programs are designed. Emotional perceptions toward unpopular animals can for example be systematically reduced within educational settings [25,43].

Surprisingly, there is a lack of studies on attitudes toward bees, although pollinator conservation seems to hog the limelight in current media and is part of school curricula in Germany and elsewhere. As mentioned before, the association of fear in regard to bees was recently investigated, but often only in combination with wasps [30,33]. Our study aims to explore how people perceive bees, in order to design effective educational programs supporting pollinator conservation. In comparison to most recent studies we use a sematic differential to investigate the perception of bees. Since we compare different age groups of students as well of beekeepers as experts, we hope to respond to all ages through this method. We focus on selected individual aspects of attitudes, namely the perceived danger, the willingness to protect bees and interest. The aim of our study is threefold: First, to investigate whether a semantic differential is an appropriate instrument for measuring the perception of bees regarding the aspects danger, conservation and interest. Second, to examine the relationship between the perception of bees as being dangerous and the willingness to protect them. Third, particularly with regard to design future effective educational programs, to investigate the perception of bees in regard to danger, conservation and interest. We focus on how age, or rather the level of expertise, influences the examined aspects.

Material and Methods

Ethics Statement

The proposed research and consent processes were approved by the Bavarian Ministry of Education ("Bayerisches Staatsministerium für Bildung und Kultus, Wissenschaft und Kunst") in April 2014 (III.9-5 O 5106/100/11). The permit number allows public review of the questionnaires used in the study. Participating schools were informed about the research conducted and provided their consent. All participants or legal guardians provided their written or oral consent to participate in this study. Data privacy laws were respected as our data was recorded pseudo-anonymously. Only the specific identifier number, based on sex, birth month and year allows conclusions on sex and age. Participants and legal guardians had the chance to reject study participation at any time.

Participants

Two groups were compared: experts and novices (Table 1). The expert group comprising experienced beekeepers was surveyed at a regional beekeeper convention. The novices consisted of subgroups determined by age and levels of expertise. We examined fourth- and fifth-grade pupils (primary school) and seventh and eighth graders (secondary school). Overall, 15 classes from five different schools participated in our study. All schools are located in major district towns or in suburbs in Bavaria, Germany. Thus, our participants were supposed of growing up in more rural regions rather than big city environments. We also collected data from university students from a variety of disciplines, excluding those with a background in biology to avoid distortions based on the level of expertise. The gender distribution was well balanced except for the beekeepers subgroup, which includes a higher proportion of male participants (Table 1). This may be due to the fact that beekeeping has long been a male domain [44].

Table 1. Sample characteristics.

		Age		Gender [%]	
	n	***M***	***SD***	**male**	**female**
Novices					
(1) Pupils (Primary School)	78	10.4	0.7	43.6	56.4
(2) Pupils (Secondary School)	321	13.6	0.7	56.7	43.3
(3) University students	100	22.8	2.4	44.0	56.0
Experts					
(4) Beekeepers	153	57.8	13.5	67.6	32.4

N = 652

Instruments

A paper-pencil-test was applied using semantic differential and open questions to collect attitudes and ideas about bees. Semantic differentials measure attitudes by asking participants to position themselves between two polar adjectives [45]. Based on adjectives adopted from Drissner et al. [46], participants were requested to position themselves on a nine-point scale between eight word pairs (e.g. “dangerous-safe”, “fascinating-boring”, or “valuable-useless”, see Table 3 in the results section) in reference to the statement “I think bees are…“. Attributes were chosen focusing on danger, utilization, conservation and interest toward bees. For a better understanding of the ideas behind participants’ attitudes toward perceived danger and willingness to protect bees, two additional open questions were applied to all participants: “Explain why bees are supposed to be dangerous/safe in your opinion?” and “explain why bees are supposed to be worthless/worth to be protected in your opinion?”. Predefined lines supported participants for the expected statement length.

Data analyses

Statistical tests were conducted in SPSS (Version 22.0). All analyses were based on non-parametric tests due to a partially non-normal distribution of variables.

The factor structure of the semantic differential was extracted using an exploratory principal-axis factor analysis. Oblique rotation was applied [47]. The following tests were

applied using factor scores, taking the dimension of single factor loadings into account. A bivariate correlation of the detected factors was calculated.

A comparison of subgroups within each factor was calculated using Kruskal-Wallis tests and pair-wise post-hoc analyses based on Mann-Whitney-U tests. Performing multiple tests we avoided cumulative Type I errors through a Bonferroni correction [48]. According to Field [47] we calculated the effect size *r*, whereby effects are interpreted as .10 'small effect', .30 'medium effect' and .50 'large effect' [49].

Qualitative content analysis was used to assess the answers we received for our open questions [50]. Based on the expert responses, we inductively built four categories with eight subcategories on the question about perceived danger (Coding guidelines, see S1 Table) and four categories and nine subcategories on the question about the willingness to protect bees (S2 Table). The novice responses were assigned deductively to the subcategories according to our coding guidelines. A person's statement could be classified into several categories.

To ensure the reliability of our categorization we randomly selected about 15% of all novice and expert answers. The analysis of inter- and intra-rater reliability, using Cohen's kappa coefficient [51], yielded scores between .84 and 1, reflecting an 'almost perfect' consistency of category assignment (Table 2) [52].

Table 2. Cohen's kappa scores for inter- and intra-reliability.

	Cohen's kappa	
	Inter-rater-reliability	**Intra-rater-reliability**
dangerous vs. safe		
experts	.90	.95
novices	.91	.93
worthless vs. worth to be protected		
experts	.91	1
novices	.84	.96

We identified categories for perceived danger and willingness to protect bees, and calculated the frequency of their occurrence. The differences between subgroups were

analyzed using Pearson's chi square tests. We calculated the adjusted contingency coefficient *C* whose range extends from 0 to 1.

Results

Factor structure of the semantic differential

The principal-axis factor analysis reduced the initial eight sematic differential pairs to three factors (based on the eigenvalue criterion surpassing 1). Items clustering under the same factor can be interpreted as follows: *Interest, danger* and *conservation & usefulness*. *Interest* and *conservation & usefulness* consisted of three word pairs each and *danger* of two word pairs. The Kaiser-Meyer-Olkin measure confirmed the sampling adequacy for the factor analysis with a 'middling' KMO value of all items (.79) according to Hutcheson and Sofroniou [53] and values for individual items greater than .61, which pass the acceptable limit of .5 [47]. Altogether, the three extracted factors explained 67.10% of the total variance. Table 3 displays the factor scores after rotation as well as the internal consistency (Cronbach's alpha) for the single factors as predictor for reliability.

Table 3. Exploratory factor analysis of the semantic differential

Factor	Item	Factor Loadings			Eigen value	Cronbach's α value
		INT	DANG	CON		
INT	*Interest*				3.88	.87
INT1	fascinating - boring	.95				
INT2	interesting - uninteresting	.87				
INT3	cool – uncool	.49				
DANG	*Danger*				1.33	.82
DANG1	harmless - weird		.91			
DANG2	safe - dangerous		.78			
CON	*Conservation & Usefulness*				1.09	.79
CON1	valuable - useless			.80		
CON2	necessary - unnecessary			.73		
CON3	worth protecting - worthless			.71		

Factor loadings below .40 are omitted; $N = 511$.

Interest and *danger* correlated negatively and significantly with a medium effect size ($r_s = -.41$, 95% BCa CI [-.48, -.32], $p < .001$). A larger effect was found for the correlation of *interest* with *conservation & usefulness* ($r_s = .69$ [.63, .74], $p < .001$) as well as for *danger* with *conservation & usefulness* ($r_s = -.52$ [-.59, -.45], $p < .001$).

Subgroups' perceptions of bees

Participants' perception of bees was investigated by applying the semantic differential. In general, individual ratings were shifted toward the positive adjective of a word pair. Expert scores in comparison to novice scores reflect a very positive attitude toward bees (Fig. 1). Attitude scores differed significantly between the novice subgroups (*interest*: $H(3) = 101.26$, $p < .001$; *danger*: $H(3) = 51.12$, $p < .001$; *conservation & usefulness*: $H(3) = 78.92$, $p < .001$).

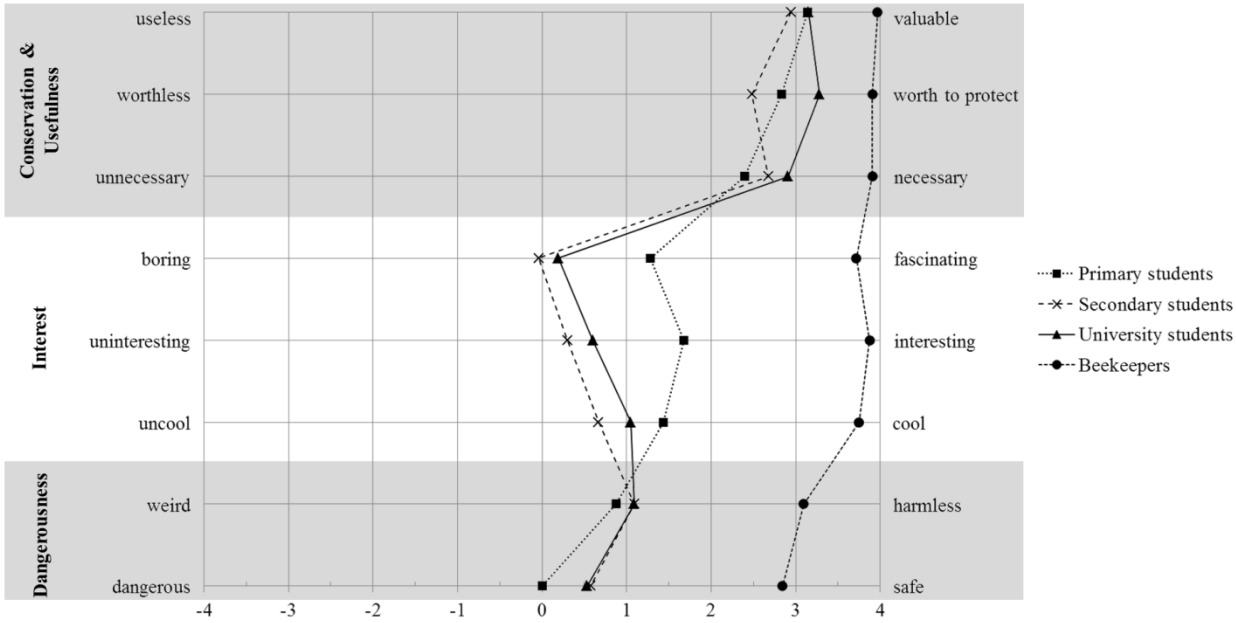

Fig 1. Attitudes toward bees: Subgroup profiles
Related word pairs of the semantic differential to be found left and right of the diagram. Adjectives reflecting a positive attitude toward bees are place on the right side.

A pairwise post-hoc comparison between all subgroups was calculated to detect differences between the subgroups' attitudes toward bees (Table 4). The beekeeping experts show a significantly higher *interest* in bees compared to the novice groups. Primary school students show a significantly higher *interest* in bees compared to secondary and university students, but both older groups do not differ from each other. Concerning the perceived *danger* of bees, the novice subgroups do not differ from each other, but perceive significantly more danger (medium to large effect size) than beekeepers. All subgroups perceived bees to be useful and worthy of conservation (*conservation & usefulness*). However, as experts also differ significantly from novices, the novice subgroups only showed a significant difference between secondary school and university students, only with a small effect

Table 4. Pairwise comparison of subgroups for the factors *Interest, Danger* and *Conservation & Usefulness* including a summary of subgroup medians and interquartiles.

			Subsamples											
			prim.			sec.			univ.			beek.		
	Mdn	IQR	*U*	*p*	*r*	*U*	*p*	*r*	*U*	*p*	*r*	*U*	*p*	*r*
Interest														
prim.	0.43	1.48	-	-	-	7079.00	<.001**	-.25	2677.50	.002*	-.23	211.50	<.001**	-.66
sec.	-0.20	1.15	-	-	-	-	-	-	13666.00	.098	-.08	283.00	<.001**	-.49
univ.	0.08	1.38	-	-	-	-	-	-	-	-	-	84.00	<.001**	-.71
beek.	1.58	0.12	-	-	-	-	-	-	-	-	-	-	-	-
Danger														
prim.	0.04	1.42	-	-	-	10598.50	.552	-.03	3469.50	.508	-.05	324.50	<.001**	-.58
sec.	0.13	1.25	-	-	-	-	-	-	15294.00	.955	-.03	1350.00	<.001**	-.38
univ.	-0.00	1.23	-	-	-	-	-	-	-	-	-	368.00	<.001**	-.58
beek.	-1.18	0.68	-	-	-	-	-	-	-	-	-	-	-	-
Conservation & Usefulness														
prim.	0.18	1.31	-	-	-	3583.50	.753	-.02	9577.50	.069	-.09	222.50	<.001**	-.65
sec.	0.03	1.24	-	-	-	-	-	-	12614.00	.007*	-.13	523.00	<.001**	-.46
univ.	0.37	0.90	-	-	-	-	-	-	-	-	-	232.00	<.001**	-.64
beek.	0.96	0.06	-	-	-	-	-	-	-	-	-	-	-	-

Mann-Whitney test *U*; after Bonferroni correction: p^* significant at α <.008 and p^{**} significant at α <.002; effect size *r* $(r = z/\sqrt{N})$

Reasons for perceived danger of bees

The qualitative content analysis revealed participants' ideas about the danger and conservation of bees. Most of the reasons concerning danger were conditional. For instance, participants mentioned that bees in general are safe, but have the potential to be dangerous ("Bees just defend their bee colony, otherwise they are safe"). The most frequent reasons mentioned for perceived danger were grouped into the categories *character of bees*, *bee sting* and *handling of bees* (Table 5).

Table 5. Choice of individual reasons for dangerousness and conservation.

Reasons [answers in %]	prim.[a]	sec.[b]	univ.[c]	beek.[d]
dangerous vs. safe				
Character of bees	18.4	24.7	35.2	56.2
Bee sting	72.4	65.9	58.2	28.6
Handling of bees	39.5	38.6	29.7	26.7
worthless vs. worth to be protect				
Bee products	59.7	38.6	39.1	18.6
Pollination (in general)	44.4	54.9	59.8	78.8
Importance of pollination for humanity	12.5	19.0	19.6	29.2
Ecological importance of pollination	8.3	19.9	44.6	41.6
Extinction of humanity	2.8	21.6	5.4	6.2

A participant's answer can be assigned to multiple categories
[a]n = 76, [b]n = 308, [c]n = 92, [d]n = 113

We conducted contingency analyses in order to see if the frequency of the mentioned reasons is significant associated to the level of expertise. In the case of the *character of bees* a significant association to the level of expertise exists ($\chi^2(3) = 43.10$; $p < .001$; $C_{corr} = .33$). Most of the experts (56.2%) mentioned that the danger of bees is connected to their character, (e.g. specific behavior like hive defense) arguing from the bees' perspective and 18.1% of the beekeepers explicitly refer to breeding a peaceful race. The number of experts mentioning the bee character as potential reason for its danger is significantly higher than the number of novices mentioning the bee character (univ. vs. beek.: $\chi^2(1) = 8.67$; $p = .003$; $C_{corr} = .29$).

Although the novice groups indicated a clear trend showing that older novices mention the bees' character more often than the younger novices, these differences were not significant (*p* significant at $\alpha < .008$ after Bonferroni correction).

Equally, we found a significant association in the category *bee sting* ($\chi^2(3) = 51.82$; $p < .001$; $C_{corr} = .36$). While the frequency of mentioning *bee sting* tended to decline with decreasing age, the novice groups did not significantly differ from each other. Only the beekeepers (28.6%) mentioned *bee sting* less frequently than the novice groups (univ. vs. beek.: $\chi^2(1) = 17.58$; $p < .001$; $C_{corr} = .41$). Nevertheless, the bee sting is the most common reason mentioned by all groups of novices, sometimes commenting that the bee sting is generally problematic (prim. 13.2%, sec. 6.8%, univ. 6.6%, beek. 1.0%) or problematic especially for persons with bee venom allergy (prim. 5.3%, sec. 13.6%, univ. 14.3%, beek. 20.0%). Only few participants commented that the bee sting is unproblematic (prim. 2.6%, sec. 8.4%, univ. 8.8%, beek. 5.7%).

The category *handling of bees* summarizes all active human behavior mentioned regarding the handling of bees (e.g. to provoke bees). Within this category the contingency analysis did not detect differences between the subgroups concerning the frequency of mentioning this reason. Nonetheless, with the level of expertise mentioning *handling of bees* tended to decrease.

Reasons for the willingness to protect bees

On the willingness to protect bees, almost all participants have the same opinion, which led us to categories dealing with reasons why bees are worth to be protected (prim. 97.2%, sec. 95.4%, univ. 98.9%, beek. 100%). The most frequently mentioned reasons were *bee products*, *pollination* in general, *importance of pollination for humanity* and *ecological importance of pollination* and *extinction of humanity* (Table 5).

Mentioning *bee products* as a reason for conservation is significantly associated with the level of expertise ($\chi^2(3) = 32.71$; $p < .001$; $C_{corr} = .29$). Most of the primary school students (59.7%) mentioned products like honey, wax, etc. as reason for protection, which differs from older students (prim. vs. sec.: $\chi^2(1) = 10.67$; $p = .001$; $C_{corr} = .26$). In general, experts mentioned bee products less frequently as a reason for conservation (beek. vs. sec.: $\chi^2(1) = 14.86$; $p < .001$; $C_{corr} = .23$) but pointed to *pollination* as major reason. We found an association between the frequency of mentioning pollination and the level of expertise ($\chi^2(3) = 26.70$; $p < .001$; $C_{corr} = .27$). Although the frequencies suggested an increasing trend along the level of expertise, the novice groups did not differ from each other significantly, only the experts (beek. vs. univ.: $\chi^2(1) = 8.74$; $p = .003$; $C_{corr} = .29$).

We counted the frequencies of mentioning pollination in general as well as the more precise statements about the importance for humanity or the ecosystem. The frequency of mentioning the *importance for humanity,* such as being able to harvest fruits or crops, is not associated to subgroups. More than 10% of the participants mentioned the importance of pollination services for humanity, whereas with age and level of expertise the importance for humanity is mentioned more often. The frequency of mentioning the *ecological importance of pollination,* however, seems distributed ($\chi^2(3) = 47.50$; $p < .001$; $C_{corr} = .35$). The subgroups are split into two clusters: the primary and secondary school students (prim. 8.3%, sec. 19.9%) and the university students and beekeepers (univ. 44.6%, beek. 41.6%) differ significantly from each other (sec. vs. beek.: $\chi^2(1) = 20.23$; $p < .001$; $C_{corr} = .30$). The latter group answered more than twice as frequently with reasons like the importance for an ecological balance or the conservation of biodiversity.

Surprisingly, we derived one category including all answers related to an *extinction of humanity*. Respondents often referred to a quote which is erroneously attributed to Albert Einstein [54] (p. 34) or their answers contained explanations about the reduction of oxygen if

the bee as a pollinator would go extinct. The frequencies of mentioning the extinction of humanity as reason for the conserving of bees are not distributed as expected ($\chi^2(3) = 33.94$; $p < .001$; $C_{corr} = .30$). The secondary school students form a distinct subgroup as they mention the extinction of humanity most often (sec. vs. beek.: $\chi^2(1) = 13.56$; $p < .001$; $C_{corr} = .25$) with every fifth student mentioning the extinction of humanity as reason why bees are worth to be protected.

Discussion

Against the background of running into danger of a biodiversity loss of important pollinators, it is crucial to better understand people's attitude toward selected species [38]. Bees as most prominent pollinators are ubiquitous in current media and school curricula. However, there is a lack of studies investigating peoples' perception of bees. The present study monitored attitudes toward bees from novices and experts regarding the perceived danger and the willingness to protect them, and also examined qualitatively collected data to understand the reasons behind the gathered perceptions.

Factors influencing the willingness to protect bees

Negative perceptions of animals are supposed to interact with individual conservation efforts [37,38]. We also found a significant relationship between the perceived danger and the willingness to protect bees. This result matches previous studies dealing with a negative influence on support of a perceived danger [12] as well as fear and disgust as emotions toward different animals [38,55]. Next to a perceived danger which affects peoples' willingness to protect, we also detected a significant correlation between willingness to protect and interest. We assume that participants displaying a more positive attitude toward bee protection are generally more interested in bees. This relationship agrees with the study of Lindemann-Matthies [56] who concludes that raising students' interest in animals represents an important

contribution to their attitude toward conservation. This effect has recently been demonstrated by Ballouard et al. [43] who implemented an educational program and observed the reduction of fear and the increase of willingness to protect even unpopular animals, like snakes. To enhance peoples' willingness to protect bees, it seems crucial to consider their perception of danger as well as their interest in the species.

Novices' and experts' attitudes toward bees

Our novice subgroups (primary, secondary and university students) show an overall positive attitude toward bees. The beekeepers, as expected, show even stronger positive attitudes toward bees (ceiling effect) concerning all three attitude aspects: interest, perceived danger and the willingness to protect bees. Thus, we regard our experts as a reference in our present study. The novice subgroups do not differ significantly from each other in their rating of danger and conservation & usefulness, but they differ concerning their interest in bees. In our study, primary school students show the greatest interest, which is again in line with earlier studies. Younger students are more interested in biological topics in general [57,58], and in living organism in particular [56] compared to older students. It is also conceivable that young student's interest in such topics is reflected in their connectedness to nature: Younger children feel also more connected to nature [59] and express more pro-environmental attitudes [60].

Why do people consider bees to be dangerous?

Our participants perceived the danger of bees as lower although earlier studies had found bees and some taxonomically related species (wasps, hornets) as perceived dangerous [31,33]. In our case both novices and experts referred to a conditional danger: participants, for instance, mentioned that bees are not a threat unless they are provoked. Most associations of novices regarding perceived danger explicitly dealt with bee stings. This result can be compared to research literature dealing with the human fear of arthropods [33]. Obviously, the sting is the crucial factor for a perceived danger of hornets, wasps and bees are considered

the most dangerous arthropods [22,61]. Not surprisingly, fear and connected negative emotions are impacted by prior experience and knowledge [23] which is reflected in our findings: Beekeepers did not mention stings as most crucial factor for conditional danger, although they may get stung more often than lay people. Novices do not have as much experience with bees as beekeepers do, and children and adolescents may obviously have negative emotions toward getting stung by bees (or other hymenoptera). Experiences of pain and swelling associated with stings from insects as well as the knowledge of existing bee venom allergies may be causes of novices' perceived danger within this context [10].

Other stated reasons for a perceived danger are the *character of bees* and the *handling of bees*. It is conspicuous that in connection with danger the *character of bees* is stated more often increasing with the expert level while *handling of bees* tends to decrease with the expert level. This fact implies a shift in focus of the argumentation from the human (handling of bees) to the bees' perspective (character of bees) along the expert level. Both perspectives obviously are influencing each other and additionally provide information about different ways of thinking about the perceived conditional danger. A more egocentric perspective found in the younger students (primary and secondary school) may also be based on differences between children and adults regarding the ability to change perspective. Adults (beekeepers and university students) tend to be less egocentric than children [62].

Concerning bee stings, it is difficult to clearly tell whether novices only refer to bees, or if they also refer to other insects which look similar to bees, like wasps or hornets. Prior studies have shown that people rate some species as fear-relevant because of misidentifying e.g. hoverflies or bumblebees for bees [22] which indicates a lack of knowledge of species. Educational programs should, therefore, focus on the following two aspects to reduce the perceived danger of bees for humans: (1) the special character of bees, or rather their breed and their behavior and (2) the ability to differentiate bees from insects with a similar appearance (e.g. wasps).

Why do people think bees are worthy of protection?

The remarkable positive perception of bees concerning conservation and usefulness in all groups was surprising, which we consider as a high willingness to protect bees. Although age affects environmental attitudes and awareness in general [63] we could not show significant age differences in the attitude toward the conservation of bees. However, the reasons why students and beekeepers think bees are worth protection are of specific interest: Particularly young students frequently stated bee products as a crucial factor for protecting bees rather than the pollination services, the most frequently stated argument of all other participants. This finding is consistent with Kellert's study [27] where the utilitarian attitude toward animals decreased and the ecological attitude increased between the 2nd and the 11th grade. In our opinion, these results also reflect the continuing lack of understanding of the abstract ecological concept primary school students hold [64,65] and the egocentric view of children [62]. Knowing about pollination is generally due to individual experience and/or educational efforts and should increase naturally with age and expert level.

Although pollination is the most stated argument in total, the subgroups still differ in the specification of their answers: While primary school students rarely mentioned the pollination service, university students and beekeepers in particular highlight the ecological importance as a major reason for protecting bees. Due to the media, the current losses of honeybee colonies raised great attention [8] and informed the public about the importance of animals' pollination services. Beside the experts, who naturally show a great interest in bees, especially older students may come into contact with media-present socio-ecological issues and may, therefore, be more sensitized toward pollinator conservation.

Interestingly, about every fifth secondary school student believes that bees need protection because humanity would die out if bees became extinct. This is an association which can be regarded as an alternative conception. Such conceptions can be described as "any conceptual difficulties, which is different from or inconsistent with the accepted

scientific definition" [66]. Often respondents explicitly referred to a quotation of Albert Einstein's: "If the bee disappeared off the surface of the globe, then man would have only four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man" [54] (p.34). While this sentence is often already used for honeybee conservation and seems to be well-known, no evidence is traceable that he ever pronounced this. It is assumed that activists attributed this sentence to Einstein in order to give the issue more credibility [54]. Although this quotation points to the importance of the species for our lives and the whole ecosystem, it is controversial because of the lack of scientific accuracy [67]. The statement about the extinction of humanity frequently appeared in the answers of secondary school students. Due to the small number of surveyed schools we assume that many secondary school respondents were classmates and thus teaching in school promoted this alternative conception. In future educational programs, a scientifically correct content should be ensured: For instance, if bees went extinct, food production would be affected and decline, but nevertheless still exist. The human race would not face extinction because the general pollination of plants is still assured through other pollination mechanisms, such as anemophily. Instead of only focusing on honeybees as pollinators, the topic offers the possibility to stimulate learners to think about effects of environmental conditions on the plant-pollinator interaction. Hence, honeybees would function as an exemplary species to explain the functionality of ecosystems in a broader context.

Methodological aspects

This study presented a short, valid and reliable instrument to measure individuals' perceptions of bees concerning different aspects. We based a semantic differential on eight word pairs clustered into three factors. Whereas the detected factor *danger* obviously describes the perceived danger of bees, the factor *conservation & usefulness* summarizes willingness to protect bees, associated with the perception of the animal's usefulness. Moreover, the factor *interest* describes a general interest in bees. Evidence for the content

validity is displayed by comparing experts and novices in Table 4. The beekeepers with more contact, knowledge and experience with bees, also showed a significantly higher interest, a lower perceived danger and a higher willingness to protect bees. This result is underlined by the answers given to the open questions in which the experts showed a significantly different response pattern. Furthermore, the overall internal consistency, shown by Cronbach's alpha, is good (≥.79).

One limitation of our study is that we just concentrated on students' and beekeepers' perceptions of bees. Since we focus on designing effective educational programs on pollinator conservation in formal learning settings, knowledge about students' attitudes is crucial. We explicitly used a potential bias of beekeepers having an enormously positive attitude towards bees in order to validate our instrument (content validity) and to get a reference that peoples' attitudes could be further improved.

Not only formal learning settings should be used to raise awareness for pollinator conservation, but also all levels of education, such as informal education and other initiatives should be addressed [7]. Therefore, our validated instrument could be applied in further studies to gather data about attitudes towards bees or other pollinators. For instance, it would be interesting and substantial getting aware of a general societies' attitude towards bees or of other specific groups such as farmers.

Conclusions

This study is the first one to focus on peoples' attitude toward bees. Considering the current and pressing need to conserve pollinating animals, it is crucial for educators to be aware of attitudes toward animals like bees. We found that perceived danger, interest and the willingness to protect bees are interrelated. Therefore, reducing fear and simultaneously increasing interest could be key aspects in educational settings. As the topic "bees as social

insects" and "pollination" are part of nearly all trans-national curricula, we strongly suggest connecting both issues and additionally consider the following aspects:

First, we recommend a learning approach with an affective focus, since negative emotions like disgust and fear can be reduced by encountering original objects [25,68]. Generally, encounters with nature foster feelings of connectedness to nature, which in turn can affect the willingness to protect nature [69]. Therefore, we recommend learning programs or interventions where students are brought into contact with living animals. Nevertheless, forcing people with greater fear to handle or touch animals against their might miss the intent and produce the contrary.

Second, we would like to emphasize the need to teach species identification skills, so that different hymenoptera genera and species can be differentiated. Thus, experienced insect stings could be attributed to the responsible species, and hence counteract misattribution.

Third, we recommend focusing on scientifically correct contents in classroom to counteract alternative conceptions. People should understand ecological interrelations and be aware of the key position held by pollinating animals.

Our study found that people show more positive attitudes toward conservation of bees than we would have expected. Besides being quite popular, bees also meet all criteria to be selected as flagship species as described by Schlegel et al.[70]: According to their criteria, bees (i) are local species in most parts of the world [71], (ii) are ecological key players because of their pollinating service [2], (iii) should be identified for example because of their prominence in most educational curricula and current media, (iv) but are not explicitly used as flagship species yet, (v) have a familiar name which is known across all ages and levels of expertise. Consequently, we strongly propose using bees, for instance *Apis mellifera*, as a flagship species for local conservation of pollinating insects.

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Supporting Information

S1 Table: Inductively built categories for the open question "Explain why bees are supposed to be dangerous / safe in your opinion?".

Category	Description	Example
Character of bees		
Breed	Argumentation refers to the breeding of a peaceful race (e.g. *Apis mellifera carnica*)	"Due to breeding, bees are safe"
Behavior of the bees	Argumentation refers to the behavior and character traits of bees. It is argued from the bees' perspective. Intentions, instincts and characteristics, which cause a bee's behavior, are also included.	"Bees just defend their bee colony, otherwise they are safe"
Health aspects		
Bee sting	Argumentation includes an explicit naming of the bee sting with or without a valuation.	"The sting is the last consequence"
Unproblematic	Argumentation includes a value judgement like the sting is unproblematic because it is rare, painless, etc.	"The amount of poison is low, the pain goes away"
Problematic	Argumentation includes a value judgement like the sting is problematic because it is unpleasant, painful, etc.	"Stings can be very unpleasant"
Allergy	Argumentation includes the aspect that a sting could be dangerous for a person with a bee venom allergy.	"Bees only pose a risk for a person with a bee venom allergy"
Handling of bees		
Appropriate human behavior	Argumentation refers to active human behavior regarding the handling of bees. It is argued from the humans' perspective.	"Bees are harmless If you don't provoke them"
Other		
Other	Any other reasons.	"Bees are the third most important animal used for production"

S2 Table: Inductively built categories for the open question "Explain why bees are supposed to be worth protecting / worthless in your opinion?".

Category	Description	Example
Achievements of bees for man & nature		
Pollination	Pollination is explicitly or implicitly mentioned with or without any further specifications	"There would be few fruits without bees"
Human importance	Pollination service is mentioned in context with the importance for humans. It includes the pollination of crop plants and fruits, food security, etc.	"Bees ensure that we have nutrition (pollination)"
Ecological importance	Pollination service is mentioned in context with the importance for the ecosystem. It includes general statements about the importance for nature as well as concrete statements about the conservation of an ecological balance, etc.	"The pollination service of bees is essential for the most important wild and cultivated plants"
Bee products	Direct products of the honeybees are mentioned, e.g. honey, Propolis, wax, etc.	"Bees are the supplier of important food products like honey or royal jelly"
Extinction of humanity	It is mentioned that humanity would die out if bees died out, often referred to an allegedly quote of Albert Einstein. This category also includes argumentations about a following reduction of oxygen.	"If bees die out mankind will follow 4 years later (according to A. Einstein)"
Conservation		
Survival of the species	The survival of the bee species is mentioned explicitly or implicitly by conservation of biodiversity regarding the bee or by protecting a creature in general.	"Bees are basically worth to be protected because they are creatures"
Other		
Unspecific arguments	Unspecific arguments about the usefulness and importance of the bees that often do not include any further explanations.	"Bees are worth to be protected because they are important for us"
Hobby & research	Keeping bees as hobby or the bee as object of study.	"You can learn a lot from them, for example social behavior"
Other	Any other reason.	"Insects rule the world"

5.4 Teilarbeit B

Schönfelder, M.L. & Bogner, F.X. (2016)

How to sustainably increase students‘ willingness to protect pollinators

Environmental Education Research
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How to sustainably increase students' willingness to protect pollinators

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Abstract

The current loss of biodiversity requires efforts to increase awareness of pollinator conservation. An important tool is education which often uses the honeybee (*Apis mellifera*) as an exemplary organism to reach this goal. Any successful module needs to focus on reducing the perceived danger associated with fear, in order to support the willingness to protect them. Using a quasi-experimental design, we investigated the effectiveness of two educational approaches: One by authentically encountering living animals at a beehive, the other by using a remote online beehive. We monitored secondary school students' (N = 354) perception of bees with respect to interest, danger and conservation as well as situational emotions (interest, well-being, boredom) during both interventions. In both cases positive effects on perception levels were observed, even when already a high willingness to protect bees existed. Using living animals in educational settings is crucial, especially when students' situational emotions need targeting. However, we achieved similar intervention results in perception levels using a remote beehive, which therefore constitutes an excellent alternative to raise awareness of the conservation of bees as pollinators.

Keywords: eLearning, honeybees, living animals, perceived danger, situational emotions, student-centre

Introduction

Conservation of pollinators

Pollination comprises a substantial natural process in terrestrial ecosystems. As the majority of crops and wild plants are dependent on pollination service of animals (Buchmann and Nabhan 1996), any loss of biodiversity will affect ecosystem balances in multiple and complex ways. For instance, a decrease of pollinator diversity would necessarily lead to genetic impoverishment (Díaz et al. 2006) with lasting negative effects on crop production and food security (Potts et al. 2010). For two decades the conservation of pollinating animals is an anchored issue in worldwide campaigns and conventions, such as at the Convention on Biological Diversity, in order to raise public awareness of the value of pollinators and their ecological service (Abrol 2012). Especially the decline of wild and domesticated bees hogs the limelight of current media and research. The extent and causes of this phenomenon are frequently and controversially discussed. Parasites, habitat loss and disease as well as pesticides seem to be the major stressors interacting to various degrees (Goulson et al. 2015). Nevertheless, it is a common understanding of scientists and policy makers that awareness of the significance of pollinator conservation is needed at local and global levels (Byrne and Fitzpatrick 2009; Potts et al. 2010). One essential tool to respond to these current challenges education (Goulson et al. 2015; Kearns, Inouye, and Waser 1998) involving both formal and informal learning settings (Abrol 2012).

Educational initiatives

Environmental education aims to encourage people to adopt pro-environmental behaviour and implement sustainable practice in a holistic and strategic way (Potter 2009). Following the Belgrade charter, environmental education must build upon peoples' knowledge, attitudes, skills, awareness of the environment and active participation (UNESCO 1976). Recent research has defined knowledge as a complex interacting construct based on different dimensions (system-knowledge, action-related knowledge and effectiveness knowledge), acting as a precursor of conservation performance (Kaiser, Roczen, and Bogner 2008). Although environmental knowledge has a behavioural effect, attitude towards nature as well as connectedness to nature are expected to act as the stronger determinants of pro-environmental behaviour (Roczen et al. 2014; Kals, Schumacher, and Montada 1999). Hence, it is

crucial that effective education modules build upon both cognitive and affective aspects including direct experiences with nature (Pooley and O'Connor 2000). The success of such programmes, in terms of promoting pro-environmental behaviour, depends on external (e.g. cultural, institutional), internal (e.g. attitudes, emotions, environmental knowledge, motivation) and demographic factors (Kollmuss and Agyeman 2002). However, negative emotions like disgust, fear or aversion can pose major barriers to effective education (Bixler and Floyd 1999).

Attitudes towards pollinating insects

Insects and other invertebrates are often perceived as disgusting and frightening creatures (Davey 1994; Kellert 1993; Prokop and Fančovičová 2013). The origin and causes of such attitudes seem manifold rooted: from biological predispositions to being prepared for potentially dangerous species (Seligman 1971; Öhman and Mineka 2001), to attitudes shaped by sets of cognitive and affective components (Eagly and Chaiken 1993). Furthermore, negative perceptions may also have their roots in myths, superstitions (Prokop, Fančovičová, and Kubiatko 2009) and cultural or even individual factors (Herzog and Burghardt 1988; Serpell 2004). Affective responses such as disgust and fear may originate in social learning (instruction, observation) (Olsson and Phelps 2007) and/or personal experiences (conditioning) (Rachman 1977). Although animals with an obvious practical value (e.g. pollinators) are perceived more positively (Kellert 1993), especially the fear of bees and other insects seems more intense in comparison to other animals (Arrindell 2000; Gerdes, Uhl, and Alpers 2009). Individual experiences with bee stings and even just the knowledge of the bee's capacity to sting may reinforce this anxiety (Schönfelder and Bogner 2016). Thus, educational initiatives should prioritise the development of methods that support knowledge and awareness (Bixler and Floyd 1999).

Environmental attitudes and attitudes towards animals are supposed to be related constructs (Binngießer and Randler 2015). The willingness to protect species can be influenced negatively by likeability (Ballouard et al. 2013; Martín-López, Montes, and Benayas 2007), negative emotions (Prokop and Fančovičová 2010; Prokop and Fančovičová 2013) and beliefs in myths and superstitions (Ceriaco et al. 2011). Schönfelder and Bogner (2016) pointed out that the individual willingness to protect bees is affected by perceived danger and interest in the species. In order to design effective

educational programmes on pollinator conservation, reducing fear and increasing interest towards pollinators are assumed to be key aspects.

Education and living animals

Earlier educational intervention studies have shown that direct encounter with living animals can positively influence individual attitudes. Bringing living animals into classrooms not only supports cognitive achievement in comparison to control groups (Hummel and Randler 2012), but also reduces aversion, disgust and fear (e.g. Bauhardt 1990; Killermann 1996; Randler, Hummel, and Prokop 2012). In particular, physical contact with unpopular animals has a positive effect on students' emotions: For instance, Killermann (1996) reported reduced fear and disgust levels towards spiders after an educational intervention with living animals kept in the classroom with the possibility to observe and touch. Outreach settings such as zoos and aquariums or field trips tend to increase the willingness to protect animals (Ballantyne et al. 2007), even when dealing with less popular organisms such as snakes (Ballouard et al. 2012). In the latter study, attitudes towards snakes were positively influenced in regard to fear, likeability and conservational concerns during a school field trip. Several studies recommend that physical contact and encountering nature is essential for promoting connectedness to nature (Liefländer et al. 2013), fostering positive attitudes towards animals (Killermann 1996; Ballouard et al. 2012) as well as increasing the willingness to protect local species (Ballouard, Brischoux, and Bonnet 2011).

Integrating modern learning settings

Animals in classrooms are often impossible to handle. Bees or other pollinating insects are difficult to keep indoors. Visiting a beehive in a school garden or at a local beekeeper site would provide an opportunity to encounter living honeybees. However, touching or closely observing these insects is impractical when entire classes are involved. Education about pollinator conservation, especially in school, requires alternative methods and learning settings.

Recent educational methods employ a variety of advances including especially new technologies, such as computers, tablets or whiteboards. Even environmental education seems to be possible with those digital tools. Especially in the field of citizen science, information and communication technologies (ICT) may serve as a link between environmental education and science

education in order to confront global challenges (Wals et al. 2014). Fauville, Lantz-Andersson, and Säljö (2014) regard both environmental education and ICT as 'newcomers' in the school context. In their review article they described which potential is shared in regard to, for instance, problem-based or action-oriented instructional practices. A variety of studies using different tools and learning activities, such as video podcasts, virtual museum or virtual environment games for indoor and outdoor purposes were monitored. Nevertheless, the impact of digital tools in environmental educational settings still needs clarification: Do digital tools indeed have the potential to raise environmental awareness and yield positive attitudes towards conservation and understanding the significance of participation in such issues? Most of the studies on the use of ICT in environmental education focus on cognitive achievement and students engagement (e.g. Hickey, Ingram-Goble, and Jameson 2009; Ruchter, Klar, and Geiger 2010; Wrzesien and Alcañiz Raya 2010) rather than on affective elements, such as emotions and attitudes concerning environmental issues (Fauville, Lantz-Andersson, and Säljö 2014).

Emotions in educational context

Emotions are not only an aspect of one's attitudes (Eagly and Chaiken 1993), but also play a crucial role in individual learning processes, a fact that has been strongly underestimated for a long time (Gläser-Zikuda et al. 2005). Emotions, such as interest, can be biographically generated (trait emotions) or evoked by situational contexts (state emotions). This distinction requires different perspectives and research methods (Ainley 2006). With regard to animals, for instance, a person could have an interest in animals because he/she grew up with pets at home (trait emotion), while interest as situational emotion could be aroused by encountering an animal in the wild or in the classroom (Fröhlich, Sellmann, and Bogner 2013).

Monitoring situational emotions within educational interventions requires some prerequisites of validities (Gläser-Zikuda et al. 2005), although positive situational emotions, such as well-being and interest, seem to positively influence learning processes, and negative emotions, such as boredom and anxiety do the contrary (Laukenmann et al. 2003). Beside an effect on cognitive achievement (Gläser-Zikuda et al. 2005; Laukenmann et al. 2003), situational emotions in educational settings seem to influence, for instance, students' intrinsic motivation (Krapp 2005) or even the individual intention

for sustainable ecological behaviour (Fröhlich, Sellmann, and Bogner 2013). Especially in the context of encountering, emotions can play an important role (Bixler and Floyd 1999; Randler, Hummel, and Wüst-Ackermann 2013). In order to design effective learning settings, situational emotions should therefore be monitored.

Aim of the present study

We implemented two educational modules aiming to increase individual willingness to protect honeybees as crucial pollinators. We addressed the following research questions:

(1) Can a short-term classroom intervention positively affect specific aspects of attitudes towards bees (interest, willingness to protect, perceived danger)?

(2) Is there a difference between encountering living animals while learning (beehive) and seeing living animals via eLearning (online beehive) in regard to situational emotions and attitudes towards bees?

(3) To what extent do situational learning emotions exert an influence on attitudes towards bees?

Methods

Participants

354 seventh and eighth graders (44.9% female; age $M \pm SD = 13.34 \pm 1.05$ years) participated in our educational programme. Data were collected from 14 classes from four different secondary schools in Bavaria, Germany. We compared two intervention groups G1 and G2: 162 students encountered living bees at a local beehive close to their school (G1), 192 students used an interactive online portal linking to a beehive (G2). School classes were included when teachers were willing to participate and parents had given permission.

Instructional design

We aimed to promote students' appreciation for bees as pollinators and as organisms essential for the environment. We focused on only one species, honeybees (*Apis mellifera*), as they are exemplary organisms for pollination and part of most German school curricula. Following Schönfelder & Bogner (2016) our programme focused on (i) affective elements in order to foster positive emotions towards bees and to reduce perceived danger, and (ii) on cognitive elements, giving students adequate information about honeybees to understand ecological interrelations and to captivate their interest for the species. The programme was structured as a student-centred learning cycle including four interdisciplinary topics with a time requirement of about 180 minutes (three school lessons) to complete. Each topic contained two working stations, one with analogue material (A) and one including tasks which could only be solved through observing honeybees (directly at the beehive) or gathering and analysing original data (from an online hive) about honeybees (B). The learning modules were designed as independent units. Within one module the two working stations were presented in a given order (from A to B or from B to A):

Module 1: "Bee-onics" - Learning from honeybees

- Construction of honeycombs and its characteristics (B)
- Usage of honeycombs in technology and architecture (A)

Module 2: Life in the dark beehive

- Bee communication in the hive (A)
- Thermoregulation; Risks and protection against heat and cold (B)

Module 3: Economic & ecological importance of honeybees

- Products from honeybees (A)
- Pollination service - bees and selected other organism (B)

Module 4: “Bye Bye Bee”- Bee mortality

- Natural causes of bee mortality as well as human impact (B)
- Conservation strategies: Possible actions for society, economy and policy (A)

Our two different interventions contained similar contents and aims, differing only in the encounter with living bees. The first group (G1) encountered the animals at a beehive accompanied by an experienced beekeeper. Students were guided by one person who was introduced to the interventions’ learning content in order to guarantee similar conditions at the beehive. Participants were required to engage in tasks such as observing the hive entrance or measuring the temperature inside the hive. Instead of encountering the living bees at the beehive, the students of the second group (G2) used the interactive online platform HOBOS (HOneyBee Online Studies, http://www.hobos.de/en). HOBOS offers the possibility of observing the animals via live streams, by the use of webcams, thermovision and endoscope cameras. Moreover, a scale for weighting the hive, a light barrier, specific sensors and further technical equipment records data of a beehive over years which can be generated on the website. These data, together with data on weather and vegetation, allow for ambitious class projects that support independent work and inquiry-based learning. For instance, in our module students were asked to observe the hive entrance via live stream and analyse data on the hive temperature over a specific time period.

We chose to compare both the original and the virtual beehive, as not every school has the possibility to encounter the living animal. All students cooperated in small groups of up to four

persons when completing the different work stations. Each student received a work book including information and tasks.

Research design and instruments

Our study consisted of a quasi-experimental design with pre-test, post-test and retention test. We applied paper-and-pencil tests one to two weeks before (T0), immediately after (T1), and six to nine weeks (depending on school holidays) after students had participated in the educational programme (T2). Table 1 shows an overview of the test design, the instruments used as well as the scale reliabilities (Cronbach's Alpha).

To measure specific aspects of attitudes towards bees, we applied a semantic differential on the perception of bees (Schönfelder and Bogner 2016). This instrument employs eight bipolar items. Participants were requested to position themselves on a nine-point scale between these word pairs in reference to the statement "I think bees are…". We used three subscales: Interest (3 items; e.g. "fascinating-boring"), conservation (3 items, e.g. "unnecessary-necessary"), and the perceived danger (2 items, e.g. "safe-dangerous").

For monitoring situational learning emotions, we used three subscales from the short version of the situational emotion questionnaire (Randler et al. 2011) which is based on a 5-point Likert scale: Situational interest (3 items; e.g. "I want to learn more about that topic"), well-being (3 items; e.g. "I was satisfied with the lesson"), and boredom (3 items; e.g. "Today I was sometimes absent with my thoughts"). The situational emotions were only measured immediately after the educational programme (T1) to assure that they directly related to programme participation.

We embedded both instruments in a larger questionnaire containing about 40 more items (e.g. on environmental attitudes, knowledge, personality factors). Each questionnaire took about 20 minutes for students to complete.

Table 1. Test design and applied instruments.

	T0 Pre test	T1 Post-test	T2 Retention test	α^a
Semantic differential on perception of bees (Schönfelder & Bogner, 2016)				
Interest	x	x	x	.86
Conservation	x	x	x	.81
Danger	x	x	x	.83
Situational emotions, short version (Randler et al., 2011)				
Situational interest		x		.77
Well-being		x		.83
Boredom		x		.84

Note. [a]Cronbach's alpha calculated from post-test values.

Statistical analyses

All statistical tests were conducted with IBM SPSS Statistics 22. For every student a mean for each of the six subscales was calculated. All further analyses were based on non-parametric tests due to non-normal distributions examined by the Kolmogorov-Smirnov test (p <.001) and analysing the Q-Q-plots. Changes within the three tests were evaluated using Friedman's ANOVA and pairwise post-hoc analyses (T0 to T1, T0 to T2 and T1 to T2) based on Wilcoxon tests. Comparisons between the two subgroups were calculated with Mann-Whitney-U tests. For these tests we additionally calculated effect sizes r according to Field (2013). Furthermore, we computed correlations between the situational emotions and short- and long-term changes in participants' perceptions of bees using Spearman's Rho. As we performed multiple tests, we adjusted for cumulative Type-I errors using Bonferroni-corrections (Bender and Lange 2001).

Results

Our analysis focused on three issues: First, we examined the effects of our educational programmes on students' perception of bees; second, we studied differences between using living animals and eLearning on perception and situational emotions; third, we determined the extent of the association between perception of bees and situational emotions due to participation.

Increase of a positive perception of bees

Participating students' interest in bees changed significantly from T0 to T1 and T2 ($\chi^2(2) = 48.248$, $p < .001$). The following pairwise comparisons showed that interest significantly changed over the short-term from T0 to T1 ($z = 6.34$, $p < .001$, $r = .29$) as well as over the long-term from T0 to T2 ($z = 4.77$; $p < .001$, $r = .21$; see Figure 1a) with small effects size. Similarly, the perceived danger score changed over the three measurements ($\chi^2(2) = 83.995$, $p < .001$). The post hoc tests revealed that the perceived danger decreased both over the short-term ($z = 8.64$; $p < .001$, $r = .38$) and the long-term ($z = 7.24$; $p < .001$, $r = .32$; see Figure 1b) with medium effect sizes. The willingness to protect bees also changed significantly between the test times ($\chi^2(2) = 42.921$, $p < .001$). However, while the pairwise follow-up test showed that there is a significant increase in the willingness to protect bees over the short-term ($z = 6.87$; $p < .001$, $r = .30$) with a medium effect size as well as over the long-term ($z = 3.71$; $p < .001$, $r = .16$) with a small effect, a decrease between T1 and T2 also appeared ($z = 4.02$; $p < .001$, $r = .18$; see Figure 1c).

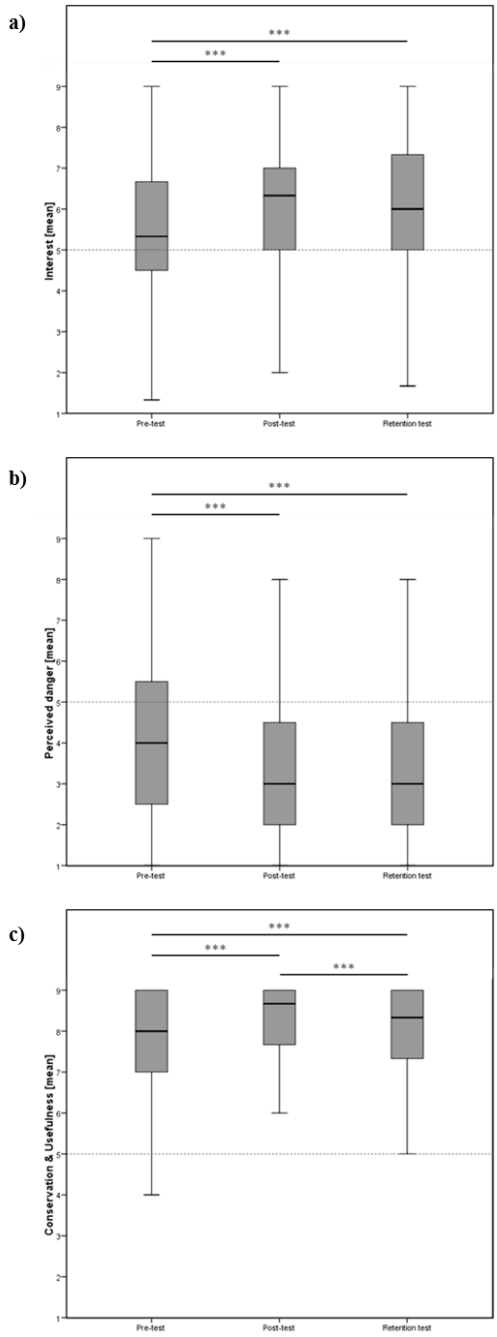

Figure 1 (a, b, c)
The perception of bees in regard to a) interest (N = 247), b) perceived danger (N = 256), and c) conservation & usefulness (N = 254). Level of significance p after Bonferroni correction: *significant at α <.017; **significant at $\alpha \leq .003$; ***significant at $\alpha < .001$.

Influences of the two applied methods

Comparison of the two intervention groups yielded a significant difference only in the short-term decrease of perceived danger: Students who had contact with the living animals (G1) significantly decreased their perceived danger (*Mdn* = -1.27) compared to the students who

participated in the eLearning programme (G2; *Mdn* = -.47). The two groups did not differ with respect to other aspects (Table 2).

Table 2. Comparison of the two intervention groups' perception of bees in short-term and long-term.

	Interest			Perceived danger			Willingness to protect		
	U	*p*	*r*	*U*	*p*	*r*	*U*	*p*	*r*
Short-term	7086.50	n.s.	.03	5460.50	<.001***	.23	7394.50	n.s.	.01
Long-term	7206.50	n.s.	.01	6534.50	n.s.	.11	7140.50	n.s.	.04

The situational interest of participating students and their sense of well-being during the programme yielded scores above the midpoint of the scale, boredom on the other hand scored below the midpoint (Figure 2). When comparing the two subgroups, we found significant differences: The well-being of participants who had contact with living animals was significantly higher ($z = 6.83$, $p < .001$, $r = .41$) and boredom was significant lower ($z = 6.59$, $p < .001$, $r = .39$) compared to the participants who used the online beehive. Concerning situational interest, the two subgroups did not differ significantly ($z = 1.94$, $p = .053$, $r = .11$).

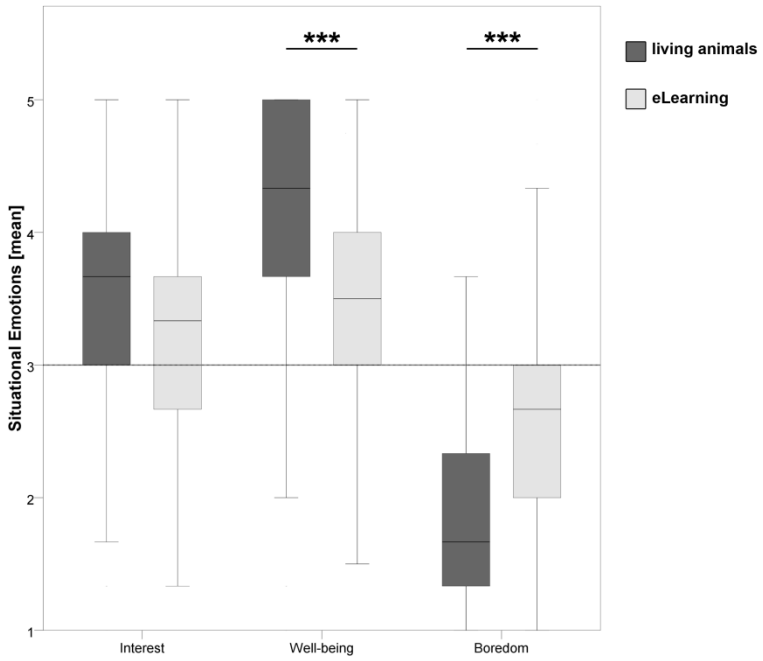

Figure 2
Comparison of situational emotions during the educational programme using eLearning and using living animals.

Situational emotions

The mean scores of the students' situational emotions with their perception of bees immediately after the intervention (T1) correlated significantly (Table 3). The highest correlation occured between the situational interest during the programme and the interest in bees ($r_s = .60$, $p < .001$) with a large effect size.

Table 3. Correlations between situational emotions and the perception of bees.

		T1 (Interest)	T1 (Conservation)	T1 (Perceived danger)
Situational emotions	Sit. Interest	.60**	.45**	-.27**
	Well-being	.35**	n.s.	-.27**
	Boredom	-.46**	-.19*	.26**

Note. $N = 276$; *indicates $\alpha < .006$, **$\alpha \leq .001$ after Bonferroni correction

Discussion

Our educational module focussing on honeybees' contribution to humans and nature in both intervention groups (living animals vs. eLearning), produced a greater willingness to protect bees as pollinators. This effect remained stable for six to nine weeks after participation. Moreover, perceived danger was shown reduced while interest in bees increased through participation. These findings build upon the study of Ballouard et al. (2012) who showed that children's positive attitudes towards snakes as unpopular and frightening animals could be increased after a one-day field trip offering direct encounter with snakes. They found a greater willingness to protect snakes as well as reduced individual fear. The timeline for such a shift was not shown to be essential as even a short-term intervention of 3 hours can obtain similar results. Awareness of such a shift potential is relevant as such programmes can easily be integrated into everyday school life.

The well-known dilemma of dichotomous perception of bees is assumed to be positively changed by different methods. Not surprisingly, encountering living animals at the beehive in a school yard had a long-lasting positive effect on interest, perceived danger and on willingness to protect bees. This is in line with recent studies concerning other living animals where positive effects on cognitive achievement are reported (Hummel and Randler 2012), as well as on emotions (Killermann 1996; Randler, Hummel, and Prokop 2012) and conservational concerns (Ballouard et al. 2012). However, by using an online beehive, we achieved similar results: Students showed greater interest, lower perceived danger and higher willingness to protect bees directly after programme participation. We obtained similar positive effects on the latter aspects in short- and long-term, except for perceived danger. Students encountering living bees perceived the animals as less dangerous compared to the eLearning group, but only immediately after the programme. Killermann (1996) presented similar results on attitude change using unpopular animals in class, and examined the use of alternative media (slides, models). Although the online beehive does not allow a direct contact with bees, HOBOS enables the observation of living animals and the investigation of a variety of hive variables from a different angle. While positive effects of ICT tools in education on motivation and cognition have already been documented, investigations of the effectiveness on the affective domain are still lacking

(Fauville, Lantz-Andersson, and Säljö 2014). Our results contribute to filling this gap, as they show that eLearning may also foster affective elements, such as positive attitudes towards animals. Future studies of eLearning may deepen our understanding by investigating additional affective factors like environmental attitudes or connectedness to nature.

Although we detected no major differences in the change of perception between the two methods, we observed strong differences in the situational emotion levels (well-being and boredom, but not situational interest) during the programme: Encountering living bees produced a better well-being and less boredom compared to the live stream observation approach. Students' well-being, which is a subjective positive feeling combining psychological, physical and social factors (Hascher 2003), is normally high during experiences with living animals (Hummel and Randler 2010; Randler, Ilg, and Kern 2005). In the same vein, students working with living organisms show less boredom, which we also observed. Unlike other study results, our students' situational interest did not differ between handling living animals and the alternative treatment of using a film (Hummel and Randler 2010). Situational interest was high in both groups. Our eLearning module, using HOBOS, seems to evoke as much situational interest as real bees do. The topic itself may cause this, as the questionnaire refers to both the 'bees' and the educational activity (living or virtual bees). Another explanation may lie in the self-regulation of the eLearning activity. Hummel and Randler (2010) investigated emotional levels during experimental tasks with living animals in comparison to a film: In contrast to watching a film, HOBOS is an interactive eLearning tool and may require more self-regulation. Since self-regulation is a mediator of emotions (Pekrun et al. 2002), any effect may originate there.

Fröhlich, Sellmann, and Bogner (2013) reported positive situational emotions in educational contexts with a significant effect on the intention of pro-environmental behaviour. We can confirm this finding since we found correlations between positive emotions and the willingness to protect bees. Both studies show that situational interest interacts strongly with conservational issues. Additionally, we demonstrated that trait interest in bees and perceived danger towards bees are affected by situational emotions, even more than the willingness to protect them. This is not surprising when taking the internal association between the three attitudinal aspects into account, as shown by Schönfelder and Bogner (2016). The correlation between situational interest at T1 and the attitudinal

interest in bees illustrates the development of individual interest. Situational interest as an affective state, evoked by the learning situation, seems to trigger the generation of a stable interest which can additionally combine cognition and motivation (Ainley 2006). Consequently, activating positive emotions in learning programmes and reducing boredom as a negative emotion should be considered when designing effective educational settings, especially with pro-environmental intentions.

To sum up, our findings suggest that attitudes towards bees can be positively supported by educational interventions. Although bees are often considered as fear-inducing and frightening animals (Gerdes, Uhl, and Alpers 2009; Breuer et al. 2015), the perceived danger can be reduced while the willingness to protect the species can be increased. Of course, it is important to offer the possibility to encounter living animals inside and outside the classroom. The benefits of the experience of nature and living organisms, especially in the affective domain of the learning process are obvious (Hummel and Randler 2012). Nevertheless, sometimes other methods are more convenient: If living animals cannot be procured, time is short, weather is poor or if the season is inappropriate, eLearning may be a good alternative. Using ICT tools in environmental education has the potential to support the development of pro-environmental attitudes. Raising awareness of pollinator conservation, both, the use of the online beehive as well as encountering living bees are appropriate tools for environmental education.

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5.5 Teilarbeit C

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Two ways of acquiring environmental knowledge: By encountering living animals at a beehive and by observing bees via digital tools

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Two ways of acquiring environmental knowledge: By encountering living animals at a beehive and by observing bees via digital tools

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Abstract

Pollination is a key process in terrestrial ecosystems. However, pollinating animals are also profoundly affected by the current loss of biodiversity, a problem that is of concern to science, policymakers and the public. One possibility to raise awareness for pollinator conservation on a local level is education. In spite of the urgent need to counteract recent losses, pollinating insects such as bees are often perceived as frightening creatures; according to the literature, negative emotions like fear may hinder successful learning processes. Thus, any educational initiative must conquer this obstacle and promote conservational knowledge. Using a quasi-experimental design, we evaluated the effectiveness of an educational programme using two different student-centred learning approaches: One by encountering living honeybees (*Apis mellifera*) at a bee hive at the school grounds (N = 162), the other by using an eLearning tool connected to a remote beehive (N = 192). We monitored secondary school students' environmentally relevant knowledge of bees, their environmental attitudes and their perception of bees in regard to conservation and dangerousness. The results indicate that both approaches lead to the acquisition of conservational knowledge in the short- and medium-term. Direct experiences with nature are regarded as crucial, but using an eLearning tool in environmental education constitutes an outstanding alternative to acquire knowledge. Adolescents with low 'green' attitudes responded positively to the online beehive, and the perceived danger of bees played no role in the learning process.

Keywords: Environmental education, cognitive achievement, eLearning, living animals, programme evaluation

Introduction

Pollination is a natural, key process in all terrestrial ecosystems that ensures the sexual reproduction of flowering plants. A majority of world food crops rely on the service of pollinators such as insects, birds and other animals. Not only luxury goods such as chocolate or coffee fall into this category, but rather fruits, vegetables and seeds contributing to nutritional security for mankind and fauna (Abrol, 2012). Hence, human well-being and the balance of nature are directly dependent on these plant-animal interactions and are affected to various degree by pollinator decline (Potts et al., 2010) and global biodiversity loss (Díaz, Fargione, Chapin, & Tilman, 2006). Insects, particularly wild and domesticated bees as primary pollinators, have attracted particular attention (Potts et al., 2010). Research and policy have already reacted, counteracting the decline of pollinators: For instance, the drivers, the extent and impact of the bee decline have been studied, but controversially discussed. Major stressors such as habitat loss, parasites or climate change are assumed to be interacting factors and their extent varies in different parts of the world (Goulson, Nicholls, Botias, & Rotheray, 2015; Potts et al., 2010). Nevertheless, there is a common understanding of the necessity of raising awareness towards pollinator conservation on global and local levels (Byrne & Fitzpatrick, 2009). Worldwide campaigns and conventions have already focussed on this issue. For instance, the first assessment of the recently formed Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) concerned itself with ‘Pollination and Pollinators associated with Food Production’, with the aim of suggesting options for action on the part of policymakers (Díaz, Demissew, Joly, Lonsdale, & Larigauderie, 2015). At the local level, public awareness for the environment in general and pollinators in particular must be raised using formal and informal education (Abrol, 2012; Kearns, Inouye, & Waser, 1998).

Environmental knowledge and attitudes

The educational aim is to convince people of the importance of our natural resources and to encourage more pro-environmental behaviour (Potter, 2009). Educational programmes must build upon different influencing factors, such as environmental knowledge and attitudes that lead to the forming of a person’s environmental competence (UNESCO, 1976). Many studies in recent decades

have been dedicated to the discovery of influences and interrelations between those factors in order to systematically foster pro-environmental behaviour. Initial theories described simple models with linear progressions from knowledge to attitudes leading to an intended behaviour (e.g. Fishbein & Ajzen, 1975). These early models have today been further elaborated, and are based on complex constructs involving a variety of dimensions and influencing variables (Kaiser, Wölfing, & Fuhrer, 1999). For instance, environmental knowledge as a precondition of conservation performance can be encapsulated in several dimensions: While 'System Knowledge' includes an understanding of natural processes within ecosystems, 'Action-related Knowledge' and 'Effectiveness Knowledge' relate more to peoples' behavioural options of conserving the environment through their own actions and knowing how effective these options would be (Frick, Kaiser, & Wilson, 2004). Acquiring knowledge within all three dimensions is essential, as factual or system knowledge alone would not necessarily lead to pro-environmental behaviour (Roczen, Kaiser, Bogner, & Wilson, 2014). In the same model involving the three dimensions of environmental knowledge, attitudes towards nature act as strong predictors of conservational performance and influence knowledge, and vice versa. It is therefore important to focus on both cognitive (e.g. knowledge) and affective (e.g. attitudes and values) learning issues in order to successfully promote peoples' conservation performance.

Effectiveness of educational initiatives

The effectiveness of educational interventions in an environmental context is well documented. The potential of educational modules on cognitive achievement has been demonstrated repeatedly. For instance, environmental knowledge focussing on different topics (e.g. plants, marine ecology, water) may be acquired through long-term (e.g. Bogner, 1998; Liefländer & Bogner, 2014) but also through short-term interventions (e.g. Fančovičová & Prokop, 2011; Sattler & Bogner, 2016). Moreover, studies have demonstrated the ability of educational settings to positively influence environmental attitudes (e.g. Bogner, 1998; Fančovičová & Prokop, 2011; Johnson & Manoli, 2010).

Many methods and approaches have been used in relevant studies and depend completely on the particular topic and on the audience: Self-regulated work stations (e.g. Sattler & Bogner, 2016; Sellmann & Bogner, 2013), field trips (e.g. Ballouard, Provost, Barré, & Bonnet, 2012; Randler, Ilg, & Kern, 2005), visits in zoos or aquariums (e.g. Ballantyne, Packer, Hughes, & Dierking, 2007) and

many more besides have been successfully implemented. Especially the impact of direct and indirect experience of nature on environmental knowledge, attitudes and behaviour has received particular attention in research (Duerden & Witt, 2010; Zelezny, 1999). A meta-analysis of Zelezny (1999) showed that environmental behaviour can be influenced more effectively by implementing classroom-based interventions compared to non-traditional settings (e.g. field trips). However, a key aspect for the effectiveness of the investigated programmes has been even more the active participation of students, which itself was more likely in classroom interventions. In contrast, Duerden and Witt (2010) reported that environmental attitudes could be more supported by direct experience with nature, whereas environmental knowledge may be increased by both direct and indirect experience. An effective way to support environmental knowledge, attitudes and behaviour would be a combination of both, methods that allow active participation and providing opportunities to experience nature. While the success of such learning depends strongly on the methods employed, internal factors such as emotions and/or motivation, as well as external (e.g. cultural, institutional) and demographic factors must also be taken into account (Kollmuss & Agyeman, 2002).

Especially in the case of learning with living animals, effective educational initiatives may be hindered by negative emotions like disgust, aversion or fear (Bixler & Floyd, 1999). Insects, including pollinators, and other invertebrates are often perceived as disgusting or frightening animals (Davey, 1994; Kellert, 1993) which may pose major barriers in environmental education. Although insects with practical value are perceived more positively (Kellert, 1993), bees nonetheless are associated with fear (Arrindell, 2000; Gerdes, Uhl, & Alpers, 2009), perhaps caused by individual experiences with bee stings or just the knowledge of bees' capacity to sting (Schönfelder & Bogner, 2016b). Reducing fear and increasing interest should be prioritised in educational settings (Schönfelder & Bogner, 2016b). Other studies report that the use of living animals has the potential to evoke learning success at a cognitive (Hummel & Randler, 2012) as well as an affective level (Ballouard et al., 2012). However, the key to success in these studies was assumed to be to direct experience in the form of physical contact.

In the case of pollinators, keeping or handling in classrooms is often difficult or impossible. Visiting a beehive, in a school garden or in the neighbourhood at a local beekeeper site, would allow

direct experience. However, active participation by close observation or touching the animals is impractical when larger classes are involved. Further difficulties could occur if weather conditions or seasons are not appropriate, or simply if no bee expert is available. Education on pollinator conservation embedded in normal school life thus requires alternative approaches and methods to ensure effective learning.

Digital tools as educational 'newcomers' easily allow active participation (Fauville, Lantz-Andersson, & Säljö, 2014). Especially in the context of citizen science, information and communication technologies (ICT) such as computers or smartphones have already been employed to engage people in environmental issues (Wals, Brody, Dillon, & Stevenson, 2014). A variety of tools are meanwhile available, from games and simulations even to virtual museum visits leading to cognitive achievement as well as students' engagement (for review, see Fauville et al., 2014). However, there is a lack of studies investigating the learning outcome concerning environmentally relevant knowledge. Due to the novelty of this approach in this field, to our knowledge there are no studies on the use of ICT tools in regard to pollinator conservation.

Purpose

The primary aim of our work was to empirically evaluate the effectiveness of an educational programme on pollinator conservation. We conducted two similar studies each using a different approach: *Study 1* examined the use of living animals, whereas *Study 2* used an eLearning setting. The following research questions were applied to both studies:

(1) Do students show cognitive achievement with respect to environmental knowledge about bees after performing an environmental education programme?

(2) To what extent do environmental attitudes and perceptions of bees affect cognitive achievement with respect to environment relevant knowledge about bees?

Methods

Participants

Our sample consisted of 354 students from secondary school, divided in two subsamples: 162 fifth to seventh graders participated in our educational programme ‘Let it Be(e)’ with living bees at a local beehive (*Study 1*; 51.23% female; age $M \pm SD = 12.72 \pm 1.12$), 192 eighth graders participated in our programme ‘HOBOS - The flying classroom’ using a remote beehive via eLearning (*Study 2*; 39.58% female; age $M \pm SD = 13.87 \pm 0.60$). 46 eighth graders served as a test-retest group without participation in either of our modules (*Control*; 52.17% female; age $M \pm SD = 13.35 \pm 0.56$). Data from 16 classes from five different schools were collected. School classes were only included when parents had given their permission and teachers were willing to participate.

Environmental education programme

The overall aim was raising awareness of pollinator conservation by using bees as an example. Students are supposed to develop appreciation for bees as pollinators, necessary organisms for humans and nature. Since it can be found repeatedly in curriculums, we considered only one species, honeybees (*Apis mellifera*). Following Schönfelder and Bogner (2016b), students’ conservational concerns towards bees can be addressed by increasing interest in the species and reducing the perceived danger of the insects. Besides including affective elements to capture students’ emotions, our programme focussed on cognitive elements by giving participants supportive information to further their understanding of ecological interrelations, as well as additional information of interdisciplinary relevance to awake their interest. We developed two three-lesson modules (135 minutes) structured each in a learning cycle. Both modules covered similar learning content, but differed in the manner of encounter with living bees.

In *Study 1* students participated in the programme labelled ‘Let it Bee’ that consisted of four hands-on workstations and a visit to a beehive located on the school grounds. Two workstations covered structure and construction of honeycombs, as well as the bees’ communication in the dark beehive. The other two workstations dealt with the bees’ usefulness for humans and nature and their death caused by human impact. Students were also introduced to the viewpoints of different

stakeholders and were asked to develop action options which help to conserve the species. One additional part in the learning cycle was the visit to a beehive. In small groups of 8 to 10, students were guided by a beekeeper who had set up a beehive in the school grounds for the required time period. The beekeeper had been instructed to conduct standardised tours of the beehive, but was allowed to answer students' questions individually. Participants closely observed the honeybees, conducted measurements and interviewed the beekeeper on prescribed interview questions (for more details, see Appendix A).

In *Study 2* students participated in the programme 'HOBOS – The flying classroom'. This learning cycle was structured into four units, each with two workstations. Similarly to *Study 1*, the content covered honeycomb construction, bees' life in the dark beehive as well as their ecological and economic importance and the current risks to which they are being exposed (see Appendix B). However, instead of visiting a beehive, students visited a remote beehive using the online platform HOBOS (HOneyBee Online Studies; http://www.hobos.de/en). HOBOS is an interactive online tool linked to a beehive that is available for research purposes. This equipment offers the possibility of observing honeybees via live streams by the use of specific cameras installed at different angles inside and outside the beehive. Furthermore, a light barrier, a scale for weighing the hive, further sensors and technical equipment recorded data over years which can be retrieved using an interactive chart tool. Together with additional information on honeybees, the live stream and the chart tool allow for student-centred learning projects. In our programme, HOBOS was embedded in half of the workstations of *Study 2*. For instance, students had to observe the hive entrance via live stream counting the outgoing honeybees in order to calculate the pollination rate during a specific time period.

Following the self-determination theory, both learning programmes were structured in workstations with small experiments and further hands-on material (Deci, Vallerand, Pelletier, & Ryan, 1991) . Groups of three or four students completed the assignments at the workstations cooperatively in a self-regulated way. To ensure an efficient work-flow we offered each workstation twice in the classroom. A workbook leads the participants through the learning cycle with information

and all tasks to be solved. After completing a workstation, students could compare their answers and solutions in a self-directed way with sample solutions on the teacher's desk.

Instruments and procedure

Our studies followed a quasi-experimental design with pre-test, post-test and retention test (Figure 1). A knowledge test was applied one to two weeks before (T0), immediately after (T1), and six to nine weeks (depending on school holidays) after participation in the programme (T2). Data of both studies were gathered using similar paper-and-pencil questionnaires. We applied an ad-hoc multiple-choice test on content knowledge consisting of 27 items. The test covers the contents of the educational programme in order to measure students' cognitive achievement. As we intended to investigate changes in environmentally relevant knowledge we only selected appropriate items (e.g. 'How can people improve the nutrition supply for bees?', 'Why could pesticides pose a risk for bees?') for subsequent consideration.

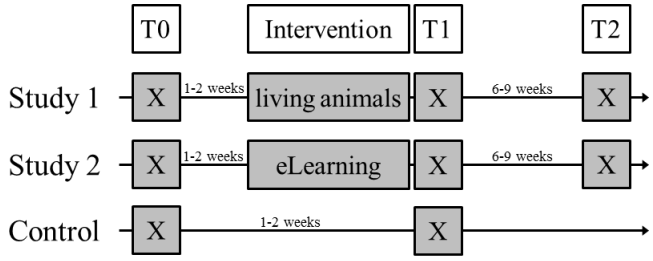

Figure 1. Study design with time frame for Study 1, Study 2 and the control group

Note: X displays an applied knowledge test.

We applied a semantic differential on the perception of bees (Schönfelder & Bogner, 2016b) to quantify attitudes towards conservation and the perceived danger of bees. Students positioned themselves on a nine-point scale between bipolar adjectives in reference to the statement 'I think bees are…'. For this study we used two subscales at test time one (T0): *Conservation & Usefulness* (CONS, 3 items, e.g. necessary – unnecessary) and *Danger* (DANG, 2 items, e.g. safe – dangerous). The Cronbach's Alpha was .78 for Conservation & Usefulness, and .80 for Danger.

Additionally, we applied (at T0) the 2-MEV scale (Bogner & Wiseman, 2006) in its modified version (Kibbe, Bogner, & Kaiser, 2014), to measure two orthogonal aspects of environmental

attitudes: *Preservation* (PRE) and *Utilisation* (UTL). In order to limit the questionnaire's length, we used only 11 (5 for Preservation, 6 for Utilisation) items of the original 20-item test battery. Shortening the 2-MEV scale has already been used successfully in recent studies (e.g. Liefländer & Bogner, 2014; Schneller, Johnson, & Bogner, 2015). The selection criterion in our study was a factor loading above .40, referring to Kibbe et al. (2014). Cronbach's Alpha was .65 for Preservation and .51 for Utilisation. For the 2-MEV-scale we used a 5-point-Likert scale with a range from 1 (strongly disagree) to 5 (strongly agree).

The three applied instruments were embedded into larger questionnaires with a total of approximately 55 items (further items on e.g. personality factors, situational emotions) taking each about 20 minutes for students to complete. The control group completed the same multiple-choice test twice (T0, T1), but without participation in any of our educational modules (Figure 1).

Statistical analyses

We selected 11 items from the multiple-choice test battery that refer to the environmentally relevant workstations in the educational programme. To analyse the quality of these ad-hoc knowledge items, we used a probabilistic model and scaled them with a simple Rasch model for dichotomous items (Bond & Fox, 2007). Each student's item response was coded 0 (incorrect answer) or 1 (correct answer). The Rasch analyses were computed using the programme ACER ConQuest 3.

All further statistical tests were conducted with IBM SPSS Statistics 22. To investigate changes in knowledge due to the programme participation, we first calculated a total score for environmentally relevant knowledge for every student for all test times. Due to a non-normal distribution using Kolmogorov-Smirnov-tests ($p < .001$) and Q-Q-plots, further analyses of both studies were based on non-parametric tests. Initially, changes in knowledge within the three test times were evaluated using Friedman's ANOVA and Wilcoxon's post-hoc analyses. We additionally calculated effect sizes *r* according to Field (2013). Second, relationships between knowledge and attitudinal variables were analysed using Spearman's Rho. Due to multiple testing, we used Bonferroni-correction to avoid cumulative Type-I-errors (Bender & Lange, 2001). Additionally, we separated two groups for each of the attitudinal factors using median splits and we compared both groups (low scorer/ high scorer) performing Mann-Whitney-U-tests.

Results

First, we present the results of the Rasch analyses of the applied knowledge scale. Second, we examine the effects of the educational programme on students' environmental relevant knowledge in both studies. Finally we determine the extent of attitudinal factors on students' knowledge due to the programme participation.

Quality of the Instrument

Initially, we scaled our knowledge item set (*post hoc*) using a dichotomous Rasch model in order to determine the scales' fit statistics, item discrimination and reliability. For all testing points the difficulty of each item was calculated, providing information about the item fitting (Table 1).

Table 1. Item fit statistic, item discrimination and reliability listed for all testing points

		T0	T1	T2
wMNSQ	Minimum	.96	.94	.95
	Maximum	1.04	1.04	1.08
t	Minimum	-.90	-.80	-.80
	Maximum	.80	.70	1.60
Item-total corr.	Minimum	.26	.31	.35
	Maximum	.51	.56	.55
Reliability (I)		.97	.92	.94
Reliability (EAP/PV)		.46	.56	.61

Note: Abbreviations found in the statistics: Mean square of the weighted item fit (wMNSQ) and its standardised (*t*) form, Reliability of the item separation (I) and of the person separation (EAP/PV).

The mean square statistic tests the relative difference of the variance between an observed item/person value and the expected value predicted by the Rasch model (Wright & Stone, 1999). With our sample size (N_{T0} = 298; $N_{T1,T2}$= 249) weighted fit mean square should range approx. between .85 and 1.15 (Wu & Adams, 2002). All our items at all testing points fall into this acceptable range. The fit *t*-statistic provides a standardized value of the fit mean square statistic taking mean and variance into account. An indication of misfit would be values outside of the range of -1.96 and +1.96 (Wu & Adams, 2002), but our *t*-values are all inside this range. Another quality criterion of our items is the

indices of discrimination, which is given by the item-total correlation. As Adams and Wu (2002) report, a discrimination coefficient higher than .25 is desirable. Finally we considered the item separation and the person separation reliability of our test for all testing points. Our scales show high item reliability indicating a good replicability with the same set of items (Bond & Fox, 2007). In contrast, our instrument only showed moderate person reliability. This index shows the replicability of the same persons with another set of items measuring the same construct.

Knowledge increase and Persistence

We observed no significant differences between the control group's environmentally relevant knowledge scores at the two test times ($Mdn_{T0} = 6.13$, $Mdn_{T1} = 6.67$). On the contrary, participants in *Study 1* showed a significant knowledge gain over three test times ($Mdn_{T0} = 5.50$, $Mdn_{T1} = 7.07$, $Mdn_{T2} = 6.71$; $\chi^2(2) = 69.634$, $p < .001$) as did students who participated in *Study 2* ($Mdn_{T0} = 6.66$, $Mdn_{T1} = 8.74$, $Mdn_{T2} = 8.22$; $\chi^2(2) = 86.964$, $p < .001$). The pair-wise comparisons of all three test times are presented in Table 2.

Table 2. Inner-group comparisons of knowledge levels

	z	*p*	*R*
[a]*Study 1*			
T1 - T0	-6.94	< .001***	-.46
T2 - T0	-6.15	< .001***	-.41
T2 - T1	-2.40	.016*	-.16
[b]*Study 2*			
T1 - T0	-8.41	< .001***	-.51
T2 - T0	-6.36	< .001***	-.39
T2 - T1	-4.54	< .001***	-.28
[c]*Control*			
T1 - T0	-1.78	n.s.	n.s.

Note: [a]$n = 115$, [b]$n = 134$, [c]$n = 46$.

Correlation of the attitudinal variables

We correlated students' mean scores of environmental values Preservation and Utilisation with the knowledge sum scores of all three test times (Table 3). While we found no relationship between the factor PRE and the applied knowledge in *Study 1*, correlations between PRE and the pre-knowledge as well as the knowledge six weeks after participation were detected in *Study 2*. Unlike PRE, the factor UTL correlated negatively with knowledge at all test times in *Study 1*. However, in *Study 2* UTL correlated negatively only with the pre-knowledge.

Table 3. Correlation between the factors Preservation/Utilisation and the cognitive knowledge

Knowledge	T0	T1	T2
Study 1			
Preservation	n.s.	n.s.	n.s.
Utilisation	-.266*	-.249*	-.266**
Study 2			
Preservation	.254*	n.s.	.243**
Utilisation	-.258**	n.s.	n.s.

Note. Spearman's correlation coefficient r_s; T0 = pre-test, T1 = post-test, T2 = retention test; Level of statistical significance *p* after Bonferroni correction: $^{**}\alpha \leq .001$; $^{*}\alpha \leq .008$.

We also correlated the individual perception of bees with respect to conservation and danger with environmental relevant knowledge about bees (Table 4). In both studies we found similar patterns. Although the factor conservation correlated significantly with the pre-knowledge and less, but still significantly, with the knowledge after six weeks, we found no relationship with the knowledge immediately after the environmental education programme. In contrast to the factor conservation, the perceived danger did not correlate at all with knowledge at any test time.

Table 4. Correlation between the factors Conservation/Danger and the cognitive knowledge

Knowledge	T0	T1	T2
Study 1			
Conservation	.385**	n.s.	.254*
Danger	n.s.	n.s.	n.s.
Study 2			
Conservation	.341**	n.s.	.217*
Danger	n.s.	n.s.	n.s.

Note. Spearman's correlation coefficient r_s; T0 = pre-test, T1 = post-test, T2 = retention test; Level of statistical significance *p* after Bonferroni correction: $^{**}\alpha \leq .003$; $^{*}\alpha \leq .016$.

When dividing the participants of each study into low and high scorer in regard to the four attitudinal variables, we found differences in knowledge levels (Figure 2 and 3). While students with high or low PRE scores in *Study 1* showed no significant differences in knowledge, students with high or low UTL values did. Participants in *Study 1* who reported of a high UTL value had less environmental relevant knowledge on bees compared to those with a low UTL score which remained stable over three test times. By contrast, students in *Study 2* with high PRE scores as well as students with low UTL scores show significant more pre-knowledge, but not after the programme.

Even more significant are the differences in knowledge levels of students with high or low conservational perception values of bees. In both studies participants with high CONS scores have significant more pre-knowledge and knowledge six weeks after the programme than those with low CONS scores. Low- and high-scorer in regard to the perceived danger of bees do not differ in their knowledge levels within both studies.

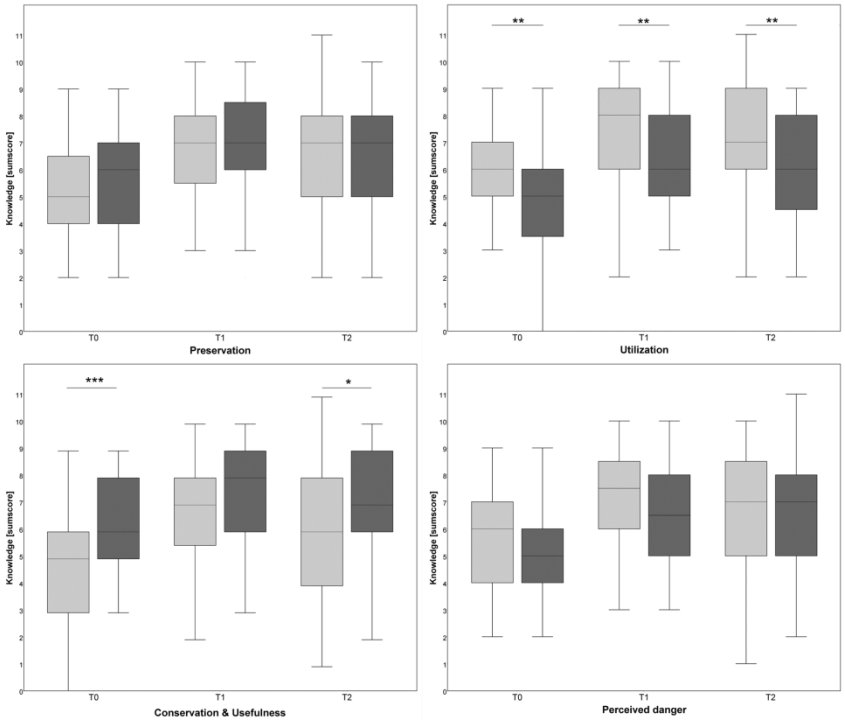

Figure 2. *Study 1*; Sum score of environmental relevant knowledge of the three test times classified into their attitudinal preference.

Note: low-scorer (light grey) and high-scorer (dark grey); T0 = pre-test, T1 = post-test, T2 = retention test.

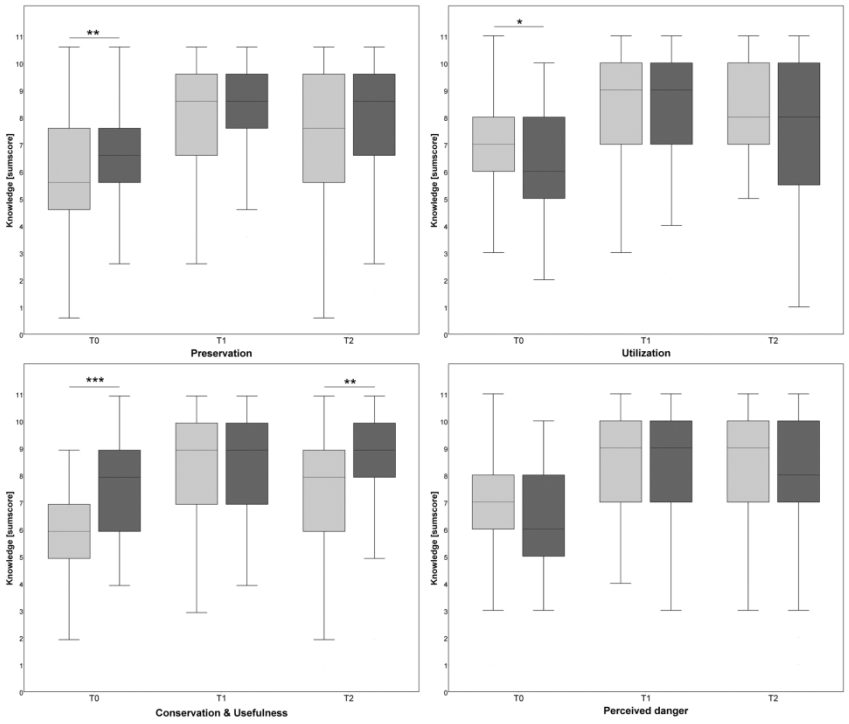

Figure 3. *Study 2*; Sum score of environmental relevant knowledge of the three test times classified into their attitudinal preference.

Note: low-scorer (light grey) and high-scorer (dark grey); T0 = pre-test, T1 = post-test, T2 = retention test.

Discussion

Two effective learning approaches

As expected, both approaches of our educational programme significantly improved students' environmental relevant knowledge about bees. It is encouraging, that even short-term interventions may promote a positive attitude towards conservation, especially against the background of the current loss of pollinators (Potts et al., 2010). The knowledge gain in our studies was assessed in the short-term, immediately after our programme, but also in the medium term, 6 - 9 weeks later. This result is in line with recent studies with environmental context: For instance, Fančovičová and Prokop (2011) reported cognitive achievement concerning knowledge of plants three months after participation in a short-term outdoor programme. Quite similarly, Sattler and Bogner (2016) demonstrated a persistent cognitive outcome in the area of marine ecology and conservational issues even six weeks after attending an instructional half-day zoo visit. In addition, there are studies demonstrating a long-term effect (6-12 months) in a more general environmental knowledge after one-day outdoor educational initiatives (Bogner, 1998; Farmer, Knapp, & Benton, 2007). However, most studies evaluating educational programmes with regard to cognitive outcome have focussed on field trips and outreach settings such as zoos or aquariums. Although encountering plants and animals and experiencing nature is crucial to support connectedness to nature, pro-environmental attitudes and behaviour (Rickinson, 2001), day to day schoolwork must nevertheless focus on conservational issues within regular lessons as well. Hence, presenting two effective approaches with respect to pollinator conservation easily adapted to normal school life is a promising message for educators.

In *Study 1* we combined our workstations with a visit to a beehive at the school grounds. The opportunity to experience the bees directly, to observe them in their natural habitat and to conduct measurements at the beehive seems to be supportive. The use of living animals in biology classes is common practise in order to acquire knowledge (Hummel & Randler, 2012), but also to reduce disgust and/or fear (Randler, Hummel, & Prokop, 2012) as well as to support positive attitudes towards the respective organism (Ballouard et al., 2012). There are only a few studies in the context of environmental education on cognitive success using living animals. The point is that most research

followed a more holistic approach to encountering nature in general (e.g. Bogner, 1998), or implemented field trips to a zoo (e.g. Sattler & Bogner, 2016) without focussing on selected species or taxonomic groups. However, Randler, Ilg and Kern (2005) reported a cognitive learning outcome after an indoor class programme and encountering five selected amphibian species during a field trip with conservational purpose; their programme reported a knowledge increase, which remained stable after 4 weeks, as did our approach. However, as Randler et al (2005) rather focussed their knowledge instrument on species identification knowledge, we validated a knowledge scale focussing on conservational issues of a species. Future studies may need to combine both, species identification skills and specific conservational knowledge as well.

As the use of living animals in educational settings sometimes depends on season, weather and appearance, we evaluated an approach using living bees via eLearning within *Study 2*. The use of eLearning in environmental education is already in place but its extensive success has been poorly studied (Fauville et al., 2014). Our approach integrating eLearning into an environmental education programme yielded positive results concerning the acquisition of environmental relevant knowledge in the short- and medium-term. Using high school students, Fauville and colleagues (2011) used a virtual laboratory in order to lead students to understand ocean acidification in the context of global climate change. The evaluation of the programme using a pre-post-test design showed significantly increased knowledge due to integration of appropriate ICT-tools. A similar large-scale study using the same tool yielded positive results concerning newly acquired knowledge (Petersson, Lantz-Andersson, & Saljö, 2013). Further studies focussing on cognitive learning due to ICT have produced very different results (Fauville et al., 2014). However, we can hardly draw any comparisons because in this domain data collection on environmental relevant knowledge has to date been neglected.

Besides using different methods in order to encounter bees, our programme has been structured in a learning cycle with workstations including experiments, further hands-on material as well as information about honeybees. Over and above our studies, learning at workstations seems to be a successful approach to teaching biological content as various interventions have also yielded positive learning outcomes in environmental context (e.g. Sattler & Bogner, 2016; Sellmann & Bogner, 2013).

Effects of environmental attitudes on knowledge acquisition

Our second research question asks whether environmental attitudes in general and perception of bees in particular have an influence on students' knowledge gain. Overall, *Study 1* differed to *Study 2* which is quite in line with the literature as there are no consistent findings in regard to environmental attitudes and knowledge (e.g. Boeve-de Pauw & Van Petegem, 2011; Liefländer & Bogner, 2016). In *Study 1* no relationship between preference for preservation and environmental knowledge about bees appeared. Although we expected this value as acting as a predictor for knowledge, similar results have been found in recent studies (Liefländer & Bogner, 2016). In *Study 2* a relationship between knowledge and preservation was found, but only before participating in our programme and 2-3 months after, perhaps because of measurement constraints, such as ceiling effect or social desirability involvement (Oerke & Bogner, 2013). However, as previous studies applying the 2-MEV consisted of samples of younger children up to twelve years (e.g. Boeve-de Pauw & Van Petegem, 2011; Fremerey & Bogner, 2015), a possible explanation for the difference before programme participation (*Study 1* vs. *Study 2*) could also be an effect which comes with higher age. Our deviating sample (*Study 2*) consisted of students aged 13-14 years. Since adolescents in this age range obtain and acquire less pro-environmental attitudes compared to younger counterparts (Liefländer & Bogner, 2014) let us assume that differences in environmental relevant knowledge may appear during the intervening years. Nevertheless, students with low preservation scores attending our HOBOS programme caught up with the knowledge level of the high-scorer. An eLearning tool like HOBOS may therefore support students with lower preservation values to acquire conservational knowledge. Although we have to keep in mind that high-scorers are possibly limited in their potential for cognitive improvement (ceiling effect), it is still encouraging to find a tool helping adolescents to acquire knowledge, especially those with lower preference for preservation.

Focussing on the second 'green' attitude value (utilisation), the pre-knowledge is related to participants' utilisation score in both studies. The lower the preference for exploitative utilisation, the more the students already knew about conservational issues with bees. This negative correlation remained stable at all three test times within *Study 1*, while in *Study 2* we detected no significant correlations after the intervention. We conclude that students with higher utilisation scores, thus

having less ‘green’ attitudes, could also catch up on the knowledge level of the low scorer in T1 by using the eLearning tool. Later on, an effect of utilitarian preferences emerges again, maybe due to high utilisation scorers failing to retain knowledge as well as the low utilisation scorers. The effect of students’ utilisation values on environmentally relevant knowledge about bees seems to be parallel to the finding in regard to preservation preferences. Unlike *Study 2*, the use of living animals addresses students equally concerning their knowledge acquisition unbiased of their preference for utilisation. This was unexpected considering recent research of Liefländer and Bogner (2016), who implemented an environmental education programme encountering nature directly. Although they also found correlations between students’ utilisation scores and their environmental knowledge, the authors arrived at a different conclusion: Children who refrain from abusing the environment would benefit more concerning cognitive achievement. In future research, the relationship and causality between environmental attitude variables and knowledge needs to be considered more closely by focussing on different age groups and extreme groups with a larger sample sizes.

Effects of perception of bees

Not only do environmental attitudes in general need consideration as the content of our educational programme is really narrow in the broad field of environmental education. It remains open to what extent individual perception of bees has an influence on students’ cognitive achievement. We focussed on participants’ perception of bee conservation and dangerousness as these two factors are relevant in this context (Schönfelder & Bogner, 2016b).

As expected, in both studies the perception of bee conservation is related to pre-knowledge, but also to knowledge 6-9 weeks after attending the programme. It is not surprising that students with positive perceptions and substantial willingness to protect also have more conservational knowledge about bees or that students with more knowledge about bee conservation are more willing to protect the species. Since we compared two statistical groups, high- and low-scorers, the convergence concerning their knowledge level in short-term and in medium-term was notable. Within both educational approaches, students showed cognitive achievement, regardless of their initial perception of bee conservation. These findings are encouraging even though we must take into account that the intervention itself predicts a change of their perception of bees (Schönfelder & Bogner, 2016a).

Moreover, it was astounding that we detected no effects at all of students' perceived danger towards bees on their knowledge level. This result is in contrast to the current literature which describes emotions such as disgust or fear as barriers for effective environmental learning (Bixler & Floyd, 1999). Outside the context of environmental education, Hummel and Randler (2010) used living animals in science class and found students showing less cognitive achievement when they felt disgusted. However, in comparison to other organisms (e.g. woodlouse, earthworm, snail) honeybees were less attributed to disgust (Randler, Hummel, & Wüst-Ackermann, 2013). There is a lack of studies examining the influence of fear and perceived danger on students' cognitive learning outcome, as far as we are aware. Future research needs to focus on this issue taking our findings into account, and examining the influences of anxiety and fear on effective environmental education.

Educational implications

Our findings clearly show the potential of educational modules to foster environmental knowledge. Teachers and educators should consider student-centred methods when preparing environmental related classes or programmes. We have shown that initiatives including direct or virtual encounters with living animals lead to cognitive achievement in the short- and medium-term. Experiencing nature directly provides further benefits such as students' high motivation (Hummel & Randler, 2012) or positive situational emotions (Schönfelder & Bogner, 2016a). Our findings, however, show additionally that cognitive achievement may be expected. Nevertheless, sometimes changes in method are desired or needed dependent upon external circumstances like weather, time, availability, etc. In these cases the use of eLearning constitutes a great opportunity in general and the use of HOBOS in the case of pollinators or bees in particular. Especially when targeting adolescents with low 'green' attitudes, eLearning tools seem to be appropriate to address them in order to yield an environmentally relevant cognitive achievement.

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Appendix 1: Description of the educational programme ‘Let it Bee’ (*Study 1*).

Duration (min)	**Name of activity**	**Content**	**Student activity**
10	Introduction	Introduction by instructor: general information about the workstations, distribution of workbooks Instructions and behavioural rules for the visit of the beehive	Paying attention, working with the introductory pages
		Learning at workstations	
20	*Wax Factory*	Construction of honeycombs, hexagon shape, mathematic considerations	Visual examination of a honeycomb, conducting two experiments on the hexagon shape of a honey cell with marbles (room volume) and with modelling clay (round vs. angular), sorting of different info- and figure-cards on the wax production and honeycomb construction process
20	*Direct Me!*	Communication in the dark hive, wagging dance	Conducting a playful experiment: testing different coding (movements, noises, odours) explaining his/her classmates a hiding place, deriving the waggle dance from learning poster
20	*Bee products*	Bee products and pollination service	Exploring a basket of bee products and info-cards, sorting of the products into categories, calculation the bees’ collection rate of nectar and their honey production
20	*Bye Bye Bee*	Human impact, action options for society, economy and policy	Deriving information on human impact on bee mortality from text and dictionary, deriving information on bee mortality and its effects in China from a magazine article, discussion with role cards viewpoints of different stakeholders, concluding action options
		Visiting the beehive	
45	Visit of the Beehive	Introduction to the beehive	General explanations about the beehive
		Observing the hive	Measuring temperature (air, inside, outside) and comparing, observing the bees’ outgoing rate and calculating the pollination rate per day
		Interviewing the beekeeper	One interview question for each student on and protections against heat and cold in the beehive and on bees’ natural causes of death
		Conclusion	Exchange forum on the interview questions, recording information

Appendix 2: Description of the educational programme ‘HOBOS - The flying classroom’ (Study 2).

Duration (min)	**Name of activity**	**Content**	**Student activity**
15	Introduction to HOBOS	Introduction by instructor: general information about the workstations, distribution of workbooks Instructions for use of HOBOS (step-by-step explanations, login details, testing live streams and chart tool)	Paying attention, working with the introductory pages and instructions for use of HOBOS, testing selected tools at the HOBOS platform
		Learning at workstations	
30	“Bee-onics” - Learning from honeybees	*(1) Wax Factory* Construction of honeycombs, hexagon shape, mathematic considerations	Working with a learning pathway at HOBOS (*eLearning*), sorting of different info- and figure-cards
		(2) Honeybees as Engineers Bionics, usage of honeycombs in technology and architecture	Conducting experiment: testing paper tubes of different shapes for stability and material consumption, sorting of info-cards
30	Life in the dark bee hive	*(1) Direct Me!* Communication in the dark hive, wagging dance	Conducting a playful experiment: testing different coding (movements, noises, odours) explaining his/her classmates a hiding place, deriving the waggle dance from learning poster
		(2) Air-condition Beehive Thermoregulation, risks and protection against heat and cold	Deriving information on the hive temperature from the HOBOS graphs, drawing new graphs with different variables (*eLearning*), answering questions about risks and protections against heat and cold in the beehive with info text
30	Economic & ecological importance of honeybees	*(1) Bee products* Different direct and indirect bee products	Exploring a basket of bee products and info-cards and sorting them into categories, calculation the bees’ collection rate of nectar and their honey production
		(2) Pollination Calculation and projection of the achievement of the pollination	Observing the bees’ outgoing rate via livestream of the HOBOS beehive (*eLearning*), calculation of the pollination rate per day, deriving information on pollination rate of diverse insects from tables and charts
30	“Bye Bye Bee” - Bee mortality	*(1) Honeybees in Danger* Natural causes of death, human impact	Watching an interview with a beekeeper explaining bees’ natural causes of death, deriving information on the incoming and outgoing rate during prescribed time periods from the HOBOS graphs (*eLearning*), working with text and an online dictionary on human impact on bee mortality
		(2) Rescue for the Honeybee? Action options for society, economy and policy	Deriving information on bee mortality and its effects in China from a magazine article, discussion with role cards viewpoints of different stakeholders, concluding action options

5.6 Teilarbeit D

Langheinrich, J., Schönfelder, M., & Bogner, F.X. (2015)

Measuring the computer-related self-concept

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Measuring the computer-related self-concept

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Abstract

A positive self-concept supposedly affects a student's well-being as well as his/her perception of individual competence at school. As computer-based learning is becoming increasingly important in school, a positive computer-related self-concept (CSC) might help to enhance cognitive achievement. Consequently, we focused on establishing a short, valid, and reliable instrument to measure the CSC by administering to German subsamples (N_{total} = 488) of three different age-groups: 8th (N = 159), 11th graders (N = 214) and university freshmen (N = 115). We succeeded in developing a one-factor-instrument with good overall reliability (α_{total} = .84) and adequate criterion validity. The scale implementation revealed a high self-concept among younger respondents. Furthermore, we observed a stereotypical difference between the CSC scores for 8th and 11th graders. Finally, we discuss pedagogical and educational considerations of the scale's implementation in school.

Keywords:

computer-related self-concept, media, learning, evaluation, secondary education, gender studies

Introduction

Research in the topic of self-concept has been well established for decades. A highly topical issue in the last years was the computer-related self-concept (CSC) because of deeply-rooted gender stereotypes (Janneck, Vincent-Höper, & Ehrhardt, 2013). Sáinz and Eccles (2012) confirmed this stereotypical difference by showing a higher self-concept of computer ability for boys than for girls. This can be a result of the gender differences in positions toward new communication technology, regularity of computer use, and self-perceived computer experience (Broos, 2005). In the case of maths, it has also been shown that parents still accept typical stereotypes, and they ascribe daughters' mathematical success to effort, and sons' to talent (Räty, Vänskä, Kasanen, & Kärkkäinen, 2002; Yee & Eccles, 1988), a fact that can possibly influence a child's CSC. A resulting gender gap may possibly affect academic outcomes in school when learning is based on working with computers. Christoph, Goldhammer, Zylka and Hartig (2015), for example, argue that specifically the CSC is playing a significant role regarding inter-individual differences in the case of computer-related learning and motivational characteristics. In addition to the differing self-concept scores between genders, there are also differences between age-groups (Marsh, Parker, & Barnes, 1985). This can be confirmed also for CSC (Sáinz & Eccles, 2012). Furthermore, Denissen, Zarrett and Eccles (2007) propose a high intra-individual association between interest and self-concept. All in all, Janneck et al. (2013) recommend interventions especially in young school ages to enable girls to develop a positive CSC. This requires an instrument for measuring the CSC in a short and easy way with a scale that is suitable for different age groups to offer the possibility for comparisons across ages.

The Computer-Related Self-Concept

In general, the self-concept is the "perception of ourselves" (Byrne, 1984, p. 429). To be more precise, it is a complex and dynamic phenomenon, a significant regulator of individuals' behavior (Markus & Nurius, 1986) and a predictor of grades (Choi, 2005). The self-concept is a hierarchical construct with the general self-concept at the top followed by the academic self-concept and the nonacademic self-concept on a second level. The non-academic self-concept includes the social, the

emotional and the physical self-concept. In contrast, the academic self-concept "refers to individuals' knowledge and perceptions about themselves in achievement situations" (Bong & Skaalvik, 2003, p. 6). Besides English, maths, history, and science self-concepts, which are regarded as essential elements of the academic self-concept (originally defined by Shavelson, Huber, & Stanton, 1976), we included the CSC to this section according to the definition of Bong and Skaalvik (2003).

The "Shavelson Model" (Shavelson et al., 1976) describes and characterizes the self-concept in detail; the self-concept reflects an individual's perception of himself or herself. The way a person acts is influenced by the self-concept which by itself is influenced by feedback from others in specific situations. It is organized, multifaceted, developmental, descriptive and evaluative and differentiable from other constructs. Often the conceptual difference between self-concept, self-efficacy and attitudes is controversial. Self-efficacy is regarded as a "context-specific assessment of competence to perform a specific task [and] a judgement of one's capabilities to execute specific behaviors in specific situations" (Pajares & Miller, 1994, p. 194), whereas the self-concept is more all-embracing and related to an individual's perceived competence especially in comparison with others (Bong & Clark, 1999; Choi, 2005; Pajares & Miller, 1994). In consequence, these constructs differ in the type of self-appraisal: The self-concept represents a norm-referenced evaluation and self-efficacy a criterion-referenced evaluation. In addition to that, the self-concept is a multidimensional construct integrating cognitive and affective components quite contrary to the unidimensional and mainly cognitive self-efficacy (Bong & Clark, 1999). Of course, this implies self-efficacy being a part of self-concept but self-efficacy and self-concept represent different constructs and should not be mistaken for each other (Bandura, 1986). Attitudes toward an object are formed informational by evaluating the various collected attributes linked to the object (Fishbein & Ajzen, 1975). This information process is independent from social interaction and makes the difference between attitudes and self-concept. Otherwise, attitudes can be seen as a part of self-concept, as attitudes and self-concept have in common to affect beliefs (Pancer, George, & Gebotys, 1992). Self-concept is a composition of an individual's self-referred attitudes (Janneck et al., 2013). As can be seen, the self-concept represents a holistic construct including several facets of a person due to its hierarchical structure.

For both genders, the self-concept is regarded as a hierarchical and multidimensional structure with the general self-concept at the top (Byrne & Shavelson, 1987). The self-concept subscales differ stereotypically: for girls, for instance, the academic self-concept is more strongly related to the English self-concept than with maths self-concept, whereas for the boys the reverse is true. In consequence, the overall academic ability of girls derives by their performance in English and the one of boys by their performance in maths (e.g., Marsh et al., 1985).

To sum up, in respect to the literature research, we define the CSC as a dynamic phenomenon, that is part of academic self-concept and which affects a person's computer-related performance and itself is affected by a person's actions as well as experiences with computers and a person's individual environment. Additionally, it includes "self-referred evaluations concerning computer-related skills, interests, experiences, attitudes, and beliefs" (Janneck et al., 2013, p. 2). Janneck et al. (2013) went further into detail and postulated the *multidimensional CSC model* based on the three-components-model of attitudes by Rosenberg and Hovland (1960). Accordingly, the CSC consists of three components influencing each other: a conative, a motivational and a cognitive component. The conative component refers to experiences during life (e.g., concrete actions or behaviors), the motivational component includes all emotions and attitudes toward computers like for example computer anxiety or individual motives for using computers, and, at least, the cognitive component which involves self-perceived computer competencies, self-efficacy and individual strategies for handling computers as well as computer-related attribution processes. Consequently, this model confirms that not only the general self but also the CSC includes many facets of oneself and, therefore, is closely related to diverse constructs such as, for example, computer self-efficacy or computer attitudes.

Measuring the Computer-Related Self-Concept

For measuring the CSC in school, a short but valid instrument is needed for suitable application in classrooms. A simple and fast evaluation of a class needs a single-factor instrument with closed answer format. Schwanzer (2002) in her developmental approach initially included 17 scales focusing on a multidimensional self-concept by modifying the Self Description Questionnaire

III (SDQ III) published by Marsh and O'Neill (1984). The Shavelson Model (Shavelson et al., 1976) with its 7 subscales served as a basis for all of these studies and could be constantly confirmed all over again until today (Brunner et al., 2010). Schwanzer (2002) aimed to adapt the SDQ III by designing a German version with scales and items relevant for adolescents, to choose a short response format, to extend the self-concept with more self-concept facets, and at least to verify the validity of the new instrument. One of the added subscales is the 12-item CSC scale which Schwanzer (2002) invented 12 completely new items taking into consideration conative, motivational and cognitive aspects of handling computers (compare Janneck et al., 2013). These items could be validated and reached acceptable reliabilities. In addition to that, she succeeded in validating the scale by applying several external criteria. In this regard, the study participants needed to specify the frequency of using computers for different purposes and the individual abilities in different areas of computer usage. The subsequent data confirmed that high CSC scores are consistent with using computers more often and higher self-perception correlates with individual computer abilities. Due to missing test-retest reliabilities of the CSC scale and insufficient sample sizes ($N = 67$), these results were not included in a published version of the self-concept instrument (Schwanzer, Trautwein, Lüdke, & Sydow, 2005). The German CSC scale is short but with a broad psychological foundation. Therefore, our study's objectives were threefold: first, to validate Schwanzer's proposed instrument for monitoring the CSC with a sufficiently big sample; second, to assure a valid and reliable instrument with a minimal number of items suitable for different age-groups; and third, to verify gender differences in the CSC by applying the validated instrument.

Material and methods

Our items originated from an internal report of Schwanzer (2002) by excluding one outdated item. The scale was implemented in German following a 4-point Likert scale response pattern and was applied using the original wording of Schwanzer (2002). The questionnaire was conducted as a traditional pen-and-paper test and was totally anonymous to minimize social desirability (Mummendey & Grau, 2008). This offered the possibility to include large sample sizes by providing

adequate anonymity and privacy to encourage participants to give more candid responses. Furthermore, the anonymity should was emphasized during the introduction of the questionnaire and the participants were told that there is no correct answer in the questionnaire because it refers to personal views.

For our exploratory cross-sectional study, we focused on lower secondary, upper secondary, and university education. Therefore, our main sample consisted of three German subsamples: (a) 8th and (b) 11th graders highest school stratification level ("Gymnasium"), and (c) university freshmen from a variety of disciplines (N = 488; see Table 1). All completed the 11-item questionnaire. A main interdisciplinary goal of the eighth grade of the highest school stratification level is to handle different types of media (ISB (Staatsinstitut für Schulqualität und Bildungsforschung München) [State Institute for School Quality and Educational Research Munich], 2004). This is why we started our exploration specifically on this age-group. After the 8th grade, handling media, including multimedia-aided learning, is required. All participants can obtain or already reached the general higher education entrance qualification ("Abitur": German equivalent of "A-Levels") that is required for university studies. In consequence, they realize the same course of education and the results remain comparable in a specific subpart of the German population. The testing was conducted in Bavaria and at the University of Bayreuth including all school classes as well as multidisciplinary lectures that give their consent. If possible, all school classes of a grade level per school were asked to complete the questionnaire for gaining more in depth cross-sectional information.

Table 1. Characteristic Values of the Sub samples Participating in the Main Study.

	N	% of overall sample	Age		Gender (%)	
			M	SD	Female	Male
University freshmen	115	23.6	21.13	2.407	58.3	41.7
11th graders	214	43.8	17.05	.676	48.6	51.4
8th graders	159	32.6	13.87	.604	39.0	61.0
Entire group	488	100.0	16.76	2.943	47.1	52.3

Validity is a broadly defined quality criterion of a test which refers to different quality aspects (Hartig, Frey, & Jude, 2012). We focused on proving criterion validity which implies the practical

relevance of test values (Hartig et al., 2012). To face criterion validity, some external criteria were applied regarding the self-assessment of abilities to handle computers, that is, the frequency of computer use. These external criteria cover all components of the *multidimensional CSC model* and, therefore, are representative for the CSC. In this regard, 117 university students (average age *M* = 21.13, *SD* = 2.41, 58.1 % women, 41.9 % men) completed the 11-item questionnaire including the external criteria. Both categories of external criteria, the frequency of using computers for different purposes and the individual abilities in different areas of computer usage, were taken from Schwanzer (2002) but items were updated. We expect that a high CSC correlates with these external criteria. Participants were required to specify the frequency of using computers for different purposes (*conative and motivational component*): (a) surfing the internet; (b) electronic communication (internet forum, email, skype, facebook messenger, ICQ, etc.); (c) use of social networks, as well as (d) programming. This questionnaire followed a 5-digit response format (1 = *never*, 2 = *less than one time a week*, 3 = *various times a week*, 4 = *less than one hour a day*, 5 = *several hours a day*).

Additionally, participants assessed their individual abilities in different areas of computer usage within a 4-digit response format (1 = *absolutely no good*, 2 = *moderately well*, 3 = *good*, 4 = *very good*; *cognitive component*). The following aspects were assessed: (a) handling of computers in general, (b) editing texts, (c) using the internet, (d) correcting faults or understanding error messages or technical defaults, (e) handling software (confident handling of file formats, software installation, downloads, etc.), and (f) handling hardware (expansion of the storage space, exchange of different components, etc.).

To exclude factors that falsify the measurement of the CSC and to prove the stability of the CSC, a test-retest reliability has to be calculated. The test-retest sample consisted of 75 upper secondary school students of the highest school stratification level with an average age of 16.84 (*SD* = 1.07, 57.3% girls, 42.7% boys). This sample completed the same 11-item questionnaire twice without evaluating the external criteria over an interval of 12 weeks.

For statistical analyses, SPSS (Version 22.0) was used. The value of the inverse items (#10 and 11) was considered as inverted value for calculations. At first an exploratory factor analysis extracted one factor, using the principal axis factoring method and a varimax rotation of all 11 items.

All items with cross-loadings as well as loading scores below .40 were removed (Stevens, 2002), the same with correlations between item and the total score below .30 (Nunnally & Bernstein, 1994) and items with α* that suggests a higher Cronbach's alpha if this item were to be deleted. The reduced scale was further analyzed as described for the 11-item scale.

To predict the scale homogeneity (Lienert & Raatz, 1994), we correlated all remaining items of the main sample with each other by using Spearman's Rho. Additionally, we calculated the average correlation of every single item with all others in the CSC scale and averaged them (Bortz & Döring, 2006).

As correlating the score of a scale with an external criterion can also provide evidence about test validity and is a direct function of the item validity estimates (Ferketich, 1991), we correlated the mean score of the CSC scale with 11 external criteria (bivariate correlation with Spearman's Rho and two tailed significance).

For evaluating the test-retest reliability, we first recalculated Cronbach's alpha for the second assessment as an indicator of internal consistency. Moreover, by correlating the scores of the first rating session with the scores obtained in a second rating session 11.95 weeks (*SD* = 2.70) later, we calculated test-retest reliability.

According to the central limit theorem, which implies that a sampling distribution has a normal distribution as the sample size gets large (usually starting from a sample size of 30), we assumed a normal distribution for our data (Field, 2013). Therefore we calculated all following results with parametric tests.

In order to be able to assess the statistical significance of the age differences, we employed univariate ANOVA for more than two independent samples. Additionally we used Tukey's post hoc test. For comparisons of gender within groups, we used *t* test.

Results

Questionnaire revision and validation

To test the sampling adequacy, the Kaiser-Meyer-Olkin (KMO) test was performed (Kaiser, 1970). A score of .80 indicated that the factor analysis achieved distinct and reliable factors (Kaiser, 1974). The exploratory factor analysis extracted three factors with an eigenvalue greater than 1 (Kaiser, 1960). The factor solution accounted for 48.8% of the total variance. Cronbach's alpha was .76 (for details, see Table 2).

Five Items (#5, 6, 9, 10 and 11) were removed due to insufficient or multiple loadings (selection details see Material and Methods). Item 7 was kept despite of its single loading on Factor 3 because none of the selection criteria applied. A repeated factor analysis based on the remaining 6 items revealed one single factor, explaining 48.8% of the variance. According to Lienert (1969), this can be labeled as remarkable. Cronbach's alpha (.84) indicated a good overall reliability (Kline, 1999). Additionally, no item deletion would have increased Cronbach's alpha substantially. The recalculated characteristic values of the CSC scale were also summarized in Table 2.

The exploratory factor analysis of each subsample also yielded a single factor. Cronbach's alpha of the CSC scale for the subsample of university freshmen was .84, of 11th graders was .84, and of 8th graders was .85. Thus, the CSC scale presents itself as suitable for adolescents of different ages.

Table 2. The CSC Scale: Loadings and Cross Loadings of Items, Correlations Between Item and the Total Score (r_{it}) and Cronbach's Alpha if Item Deleted (α*) Before and After Revision.

		Original CSC Scale					Revised CSC scale		
		Factor loadings			r_{it}	α*	Factor loadings	r_{it}	α*
	Item	1	2	3					
1	It's very important for me to work with computers.	.638			.585	.722	.664	.603	.822
2	I really enjoy gaming or working with a computer.	.670			.652	.715	.774	.704	.803
3	I'm really interested in using computers.	.785			.686	.707	.844	.756	.790
4	Handling computer-software is a very important aspect for me.	.790			.649	.711	.760	.682	.806
5	Good computer skills are important for my personal progress in school/studies.	**.368**			.321	.755			
6	While I'm working with the computer, I often do not notice how quickly time passes by.			**.399**	**.287**	.760			
7	I willingly forego other activities for spending time with the computer.			.826	.504	.732	.518	.476	.846
8	I'm pretty inventive in dealing with computers.	.580			.489	.734	.575	.527	.836
9	I would name myself a computer expert.	**.532**	**-.455**		.497	.733			
10	If I have to learn to handle a new computer programme, I quickly feel overstrained.		.436		**-.017**	**.795**			
11	I only start using the computer, if I really have no other choice.		.811		**-.014**	**.791**			

Note. Underlined results were insufficient.

The correlation matrix among items gives evidence about the scale homogeneity (Table 3). As Ferketich (1991) reports, item to item correlations more than .300 and lower than .700 would be desirable. In consideration of the Bonferroni correction, we used .001 as our criterion for significance. In any case, this assumption was confirmed. Although the interitem correlation of Item 7 and 8 didn't reach the .30-limit, all average correlations were sufficiently close to the given guidelines. Thus, nearly all items are essential as well as sufficiently related and therefore contribute to measurement of the core factor. This explains the appropriate value of .467 for scale homogeneity of the CSC scale.

Table 3. Correlation Matrix Among Items.

Item	1	2	3	4	7	8	
1	1.00						
2	.556	1.00					
3	.531	.629	1.00				
4	.513	.566	.675	1.00			
7	.330	.454	.422	.329	1.00		
8	.346	.445	.490	.452	.262	1.00	
r_{ii}	**.455**	**.530**	**.549**	**.507**	**.359**	**.399**	$\mathbf{r_{ii}^* = .467}$

Note. Significance in each case <.001, r_{ii} = average correlation of the item with all the others in the CSC scale, r_{ii}*= mean value of all average correlations.

To consider the correlations between the external criteria and the mean score of the CSC scale, we used a significance barrier of .005 with regard to the Bonferroni correction. Nevertheless, all external correlates remain significant and range from r = .279 to r = .491 (Table 4). Accordingly, we also showed a substantial correlation between the mean score of the external criteria and the mean score of the CSC. Correlations provably exist which means that the characteristic to be measured relates to each requested external criteria. In consequence, the criterion validity could be confirmed.

Table 4. External Correlates of the CSC Scale.

External criteria			r_a	r_b
Please specify, how often do you use the computer for the following purposes:	1	Surf the internet	.491	.526
	2	Electronic communication	.318	
	3	Use of social networks	.298	
	4	Programming	.328	
How do you assess your abilities in the following areas of computer usage:	5	Handling of computers in general	.483	.512
	6	Editing texts	.279	
	7	Using the internet	.288	
	8	Correcting faults/understanding error messages/technical defaults;	.375	
	9	Handling software	.478	
	10	Handling hardware	.412	

Note. r_a = correlation coefficient between every external criterion and the mean score of the CSC, r_b = correlation coefficient between the mean score of the external criteria and the mean score of the CSC , significance in each case $p \leq .005$.

The test-retest reliability for the CSC scale within the test-retest sample yielded a Cronbach's alpha of .82 which reflects the internal consistency following the repeated assessment (.80). The statistical correlation analysis reveals acceptable test-retest reliability with a value of .75.

Implementation of the CSC Scale in Different Age-Groups

A univariate ANOVA showed that age correlated with the CSC, $F(2, 485) = 10.74$, $p < .001$, $\omega = .20$ (Figure 1). Tukey's test verified this result and illustrated a significant difference between 8th and 11th graders ($p < .001$) as well as a significant difference between the 8th graders and the university students ($p < .001$). The CSC mean scores of the 11th graders and the university freshmen didn't differ significantly ($p = .765$). For more detailed information, we distinguished the age-groups by gender (Figure 1). The CSC scale showed a single factor and a good overall reliability for girls (.78) and for boys (.86) (Kline, 1999). Overall, the mean test score of the male participants varies between the different ages, $F(2, 254) = 12.05$, $p < .001$, $\omega = .28$. This could not be confirmed for the female participants; $F(2, 229)$, $p = .075$, $\omega = .12$.

Although there were no significant differences between gender of the university students, we observed that the male 11th graders reached a higher CSC ($M = 2.75$, $SE = .65$) than the female 11th graders ($M = 2.29$, $SE = .54$). This difference, -.46, BCa 95% CI (-.62, -.30), was significant, $t(212) = -5.65$, $p < .001$, $d = .77$. Similarly with the female 8th graders ($M = 2.43$, $SE = .53$) and the male 8th graders ($M = 2.99$, $SE = .63$), the difference, -.56, BCa 95% CI (-.75, -.37), was also significant, $t(157) = -5.81$, $p < .001$, $d = .94$.

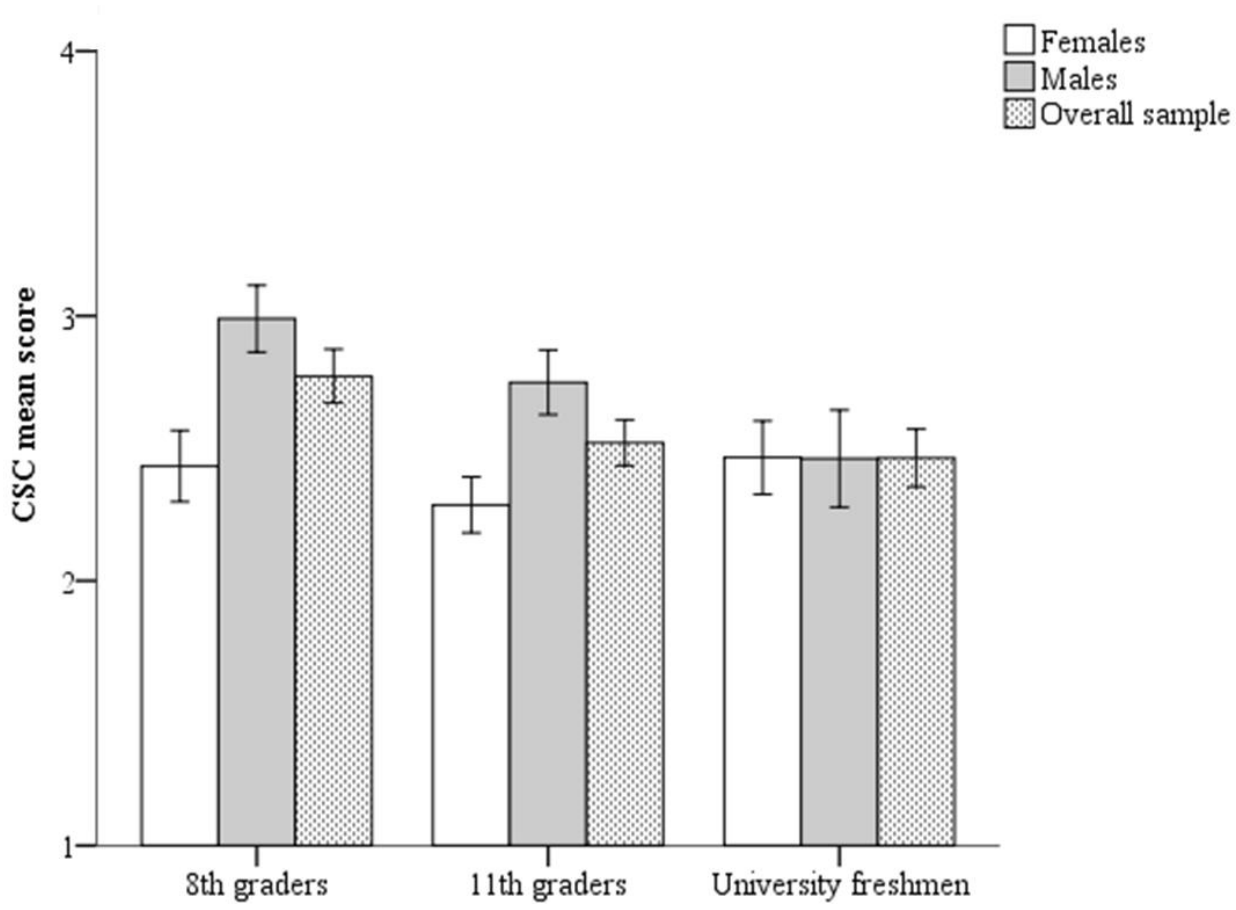

Figure 1. Comparison of overall mean test scores by age-group and gender.
Note: bars are 95% confidence intervals.

Discussion

This study presented a German valid and reliable single factor scale with a minimal number of items to measure the CSC. We succeeded in validating the unpublished CSC scale of Schwanzer (2002) for different gender and age-groups of the German "Gymnasium" by reducing the number of items from 12 to 6 showing an overall good test-retest-reliability and internal consistency. The implementation of the scale showed that 8th graders demonstrated a higher self-concept than 11th graders and even the university freshmen. Similarly, a stereotypical gender difference, with a higher CSC for male participants, was found for the 8th as well as for the 11th graders. This difference vanished for university students.

Questionnaire Revision and Validation

The CSC is one component of the total academic self-concept. Therefore, it should not consist of more than one single factor, especially under consideration of implementing the scale in a school context. In general, the validation of a scale should result in an instrument as short as possible while maintaining acceptable support for its validity and reliability (Ferketich, 1991). We obtained an instrument with a single-factor structure with moderate to good factor loadings measuring the CSC. For approval of criterion validity, university student's responses about individual computer usage were monitored. According to our expectations, the external criteria correlated significantly with the CSC scale which supports the scale's criterion validity. Those who often use the computer for a variety of purposes (e.g., surfing the internet, electronic communication or using social networks) also have a high CSC, as do those who assess their abilities for various areas of computer usage as good. In this case we required girls to be engaged in equal tasks of computer use compared to boys, as it was shown by Vekiri and Chronaki (2008). These external criteria were in line with the *multidimensional CSC model* (Janneck et al., 2013) and confirm that the validated scale measures is based on conative, motivational and cognitive components of the CSC. This also includes related constructs like emotions and attitudes toward computers or self-efficacy.

The internal consistency, shown by Cronbachs's alpha, is overall good (.84), as it is for all three subsamples and both genders. Moreover, the measured test-retest reliability estimate was acceptable which implies a demonstrable stability of the CSC and an adequate dependability and accuracy of the assessment method. This points out that the CSC is not influenced by actual external variables during the test situation. Furthermore, all items showed an appropriate scale homogeneity which is a supporting argument for both validity and reliability (Ferketich, 1991).

For analyzing the gender specific CSC we also validated the shortened CSC scale separately for females and for males. Our results supported a single factor solution and a good overall reliability for both genders of every age-group.

The CSC scale was one of 17 subscales proposed by Schwanzer (2002) with the goal to evaluate the total self-concept. Due to small sample sizes and missing test-retest reliabilities the CSC scale was the only one that was never completely validated. Consequently, we had first focused on the

validation of the CSC scale. This scale now offers the possibility to be implemented with the 16 other subscales to evaluate the total self.

Implementation of the CSC Scale in Different Age-Groups

In our study, the freshmen's CSCs did not discriminate between girls and boys. This is in line with the computer usage study of Imhof, Vollmeyer, and Beierlein (2007). In consequence, the CSC can be yield a nonstereotypical self-concept rating in university courses despite some disagreement in the literature. Baram-Tsabari and Yarden (2011), for example, stated that the typical stereotypes are not completely developed until the end of high school. This would result in a lower CSC for girls and a higher one for boys (compare also Sáinz & Eccles, 2012).

On average, for both genders, older subjects score lower in the CSC. This is in line with the literature (Comber, Colley, Hargreaves, & Dorn, 1997). In the separate subsamples of 8th as well as the 11th graders, our study demonstrates stereotypical gender differences in the CSC scores. This is in line with the results of Sáinz and Eccles (2012) who also demonstrated a stereotypical gender gap. The only difference is that, in contrast to our study, the self-concept increases for male students over time whereas the self-concept of the female respondents decreases. Our results were inverse. By comparing the CSC of both genders in the three explored age-groups, the CSC scores became aligned in conjunction with a decrease of boys' CSC and an increase in CSC experienced by girls.

The Scales Relevance in School

Our study points out gender differences in the CSC in school relevant ages. These differences in self-concept scores may play a significant role in regard to inter-individual differences in computer-related learning and motivational characteristics as well as interest (Christoph et al., 2015; Denissen et al., 2007; Marsh, Trautwein, Lüdke, Köller, & Baumert, 2005). At least, the self-concept shapes the academic and occupation choices later-on (Lips, 2004), influences individual goal-setting and choices of future profession. These preferences by themselves may additively explain specific (school) subject motivation (Markus & Nurius, 1986). Therefore, an equivalent self-concept of both genders is necessary to enable all students the same chances especially by taking into consideration technology

courses and the fact that computer-based teaching and learning is becoming an increasingly important role in school. This study indicates that a push to increase the CSC of girls is needed while maintaining the high CSC level of boys. To guarantee individual and optimal support within the terms of differentiation, a tool for evaluating individual CSC scores is required to adapt teaching methods. By displaying the current CSC status of students, the CSC can be considered for adapting teaching to each class, for example, by differentiation or offering several learning aids with varying difficulty in computer-based learning-units. In consequence, high CSC-achieving students are not under-challenged anymore, while all other students find a better chance to reach high cognitive achievement levels. Since the self-concept is strongly connected to individual experiences, students can improve their individual self-concept by successfully mastering new learning contents by using computer-based learning in this way of teaching (Janneck et al., 2013). This increase in CSC is not only relevant for following education but also in future profession that will be more and more include working with computers. Therefore, teaching in younger ages should focus on evaluation of CSC and lead to a more positive CSC.

The scales shortness allows an easier application in school contexts. This includes implementations from a teacher's side to adapt their individual teaching efforts as well from researcher's side to evaluate teaching forces with computers. Furthermore, long-term studies with multiple completions of the questionnaire become more feasible allowing comparisons over time. This can be used, for example, to evaluate the effectiveness of different teaching methods using the computer or the impact on the girls' and boys' CSC.

Potential Limitations

Our 4-digit response format of the CSC scale allows two points of view: On the one hand, the absence of a (undecided) midpoint can avoid responses affected by social desirability, but on the other hand, distortions in the results are possible (Garland, 1991). Our present study does not allow any decision about preferences.

A cohort effect in our study cannot be excluded due to an age gap of seven years in our sample (while technical progress proceeds very rapidly). Therefore, we would favor longitudinal study

in the future. Additionally, to verify a shift of the CSC over ages, more age-groups are required, especially in younger ages. To increase the representativeness of the results, more data from different school types and countries are needed. Additionally, the construction of self-concept is more than just the reflection of absolute performance. Flexible selection and processing information where also personality traits come in, was shown to be important for develop a completive self-concept (Byrne, 1996; Gniewosz, Eccles, & Noack, 2011; Jonkmann, Becker, Marsh, Lüdtke, & Trautwein, 2012). In the following, the Big-Fish-Little-Pond-Effect (BFLPE) and social desirability shall be exemplary portrayed. Equally abled students show lower academic self-concepts when being part of a high-achieving class than being part of a low-achieving one. This phenomenon is well-known as the BFLPE (Marsh, 1987; Marsh & Parker, 1984). In our study we can't rule out the BFLPE having an impact on our results because we have not collected additional data about achievement-levels of each participating class of our study. Furthermore, social desirability can lead to a falsification of results (Mummendey & Grau, 2008; Rost, 1996). Personality tests often are easy to see through. This may induce that self-monitoring, for example, with rating scales, is more similar to an ideal self than the real self. Additionally, this effect varies with age, gender and class affiliation. To minimize an influence of social desirability, the questionnaire of this study was implemented in a pen-and-paper format by ensuring anonymity. But to prove the direct influence of social desirability on the results of the study a control scale should be added to the questionnaire, if the questionnaire's volume does allow (see, Oerke & Bogner 2013). Mummendey and Grau (2008) even report that socially desirable answers are part of a measured construct especially in self-concept research. All in all, this study cannot give evidence about a possible influence of social desirability but tried to minimize the impact by adapting the execution of the survey.

Finally, we propose to implement our valid and reliable scale together with the scale for measuring the self-concept of computer ability of Zarrett and Malanchuk (2005) in order to examine whether these both are based on the same construct and to face convergent construct validity. To go even into more detail and to confirm the *multidimensional CSC model*, the "attitudes toward computer usage" scale (ATCUS v 2.0) by Morris, Gullekson, Morse and Popovich (2009) and the "computer

user self-efficacy" scale (CUSE) by Cassidy and Eachus (2002) may add strengths into further surveys.

Conclusion

The presented instrument provides a reliable and valid way for educators and teachers to rapidly obtain information about computer-related issues including self-concept preferences. The advantage of this scale is its broad psychological foundation and that it can be implemented on a stand-alone basis as well as in combination with other subscales to gain a holistic vies of self-concept (Schwanzer et al., 2005).The scale's shortness allows its application in classrooms without disturbing teaching flows and, thus, provides a huge potential to optimize teaching according to the individual needs of students.

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ANHANG

Fragebögen

A Fragebogen zur Einstellung gegenüber Bienen

Der Fragebogen wurde zur Erhebung der Einstellungen bezüglich wahrgenommener Gefahr, Interesse und Schutz der Bienen bei Schülern der Primar- und Sekundarstufe, Studenten und Imkern eingesetzt. Nur bei den Schülern der Sekundarstufe wurde das verwendete Instrument in mehrere Fragebögen integriert. Exemplarisch wird der Fragebogen für die Primarstufe gezeigt, dessen Deckblatt bei Sekundarstufe, Studenten und Imkern gemäß dem Alters und der Stellung angepasst wurde.

B Schülerfragebogen zur Intervention

Der Schülerfragebogen enthält neben dem Semantischen Differential zur Einstellung gegenüber Bienen zu jedem Testzeitpunkt auch Wissensfragen. Zusätzlich wurden einmalig Umwelteinstellungen (Vortest) und Lernemotionen (Nachtest) abgefragt.

Der Fragebogen wurde gleichermaßen zur Evaluation der beiden Programme *Let it Bee* und *HOBOS - Das fliegende Klassenzimmer* eingesetzt. Der einzige Unterschied bestand im austauschbaren Wortlaut bei der der Skala zur Erfassung von Lernemotionen. Exemplarisch wird der *Let it Bee*-Fragebogen gezeigt.

C Fragebogen zum Computerselbstkonzept

Die Skala zur Erfassung des Computerselbstkonzeptes war in den Schülerfragebogen integriert, der zur Evaluation des Programms *HOBOS - Das fliegende Klassenzimmer* eingesetzt wurde. Zudem wurde ein Studentenfragebogen erstellt, der hier exemplarisch gezeigt wird. Dieser enthielt zusätzliche Fragen über Außenkriterien, die zur Validierung der Skala notwendig waren.

A Fragebogen zur Einstellung gegenüber Bienen

Liebe Schülerin, lieber Schüler,

vielen Dank, dass Du an dieser Befragung teilnimmst!

Dieser Fragebogen ist Teil einer wissenschaftlichen Untersuchung und streng vertraulich. Er wird **nicht** von Deiner Lehrkraft benotet.

- Bearbeite den Test bitte **alleine** und **sorgfältig**.
- Kreuz die Antwort an, die **Deiner Meinung nach** richtig ist.
- Wenn Du Dich beim Ankreuzen vertan hast, dann mal das Kästchen vollständig aus und kreuz ein anderes an.
- Wenn Du fertig bist: Kontrollier bitte, ob Du alle Seiten ausgefüllt hast!

Datum: _____

In welcher Klasse bist du?	☐☐ (z.B. 4 B)
Bist du ein Mädchen oder Junge?	○ Mädchen ○ Junge
Wie alt bist du?	☐☐ Jahre

Lies Dir die folgenden Wortpaare durch und gib eine persönliche Einschätzung, was Du von Bienen hältst.

Pro Wortpaar immer nur **1 Kreuz (X)** setzen!

Beispiel:
Bienen finde ich…

hübsch			X			hässlich
natürlich		X				unnatürlich
angenehm				X		nervig

Bienen finde ich…

langweilig										spannend
gefährlich										ungefährlich
unnütz										nützlich
eklig										niedlich
uninteressant										interessant
unbedeutend										notwendig
schlecht										gut
blöd										toll
unheimlich										harmlos
unwichtig										schützenswert

Bitte begründe, warum Du Bienen eher gefährlich/ungefährlich findest?

_____

_____

_____

_____

_____

Bitte begründe, warum Du Bienen eher unwichtig/schützenswert findest?

_____

_____

_____

_____

_____

VIELEN DANK FÜR DEINE MITARBEIT!

B Schülerfragebogen zur Intervention

Fragebogen zum Unterrichtsprojekt

„Let it Bee“

Liebe Schülerin, lieber Schüler,

vielen Dank, dass Du an dieser Befragung teilnimmst!

Dieser Fragebogen ist Teil einer wissenschaftlichen Untersuchung und streng vertraulich. Er wird **nicht** von Deiner Lehrkraft benotet.

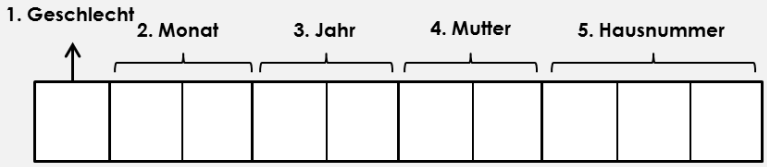
- Bearbeite den Test bitte **alleine** und **sorgfältig**.
- Benutze einen Füller oder Kugelschreiber.
- Kreuz die Antwort an, die **Deiner Meinung nach** richtig ist.
- Wenn Du Dich beim Ankreuzen vertan hast, dann mal das Kästchen vollständig aus und kreuz ein anderes an.
- **Es dürfen an keiner Stelle Angaben über Dritte gemacht werden.** Das heißt, schreibe nichts über Deine Familie, Freunde oder Bekannte. Es zählt nur Deine Erfahrung und persönliche Meinung.
- Wenn Du fertig bist: Kontrollier bitte, ob Du alle Seiten ausgefüllt hast!

Dein persönlicher Code:

Datum: .....

Dein persönlicher Code besteht aus:

1. Geschlecht *(**W**eiblich oder **M**ännlich)?*
2. In welchem **Monat** hast du **Geburtstag** *(z.B. 01, 02, 03, … , 09, 10, 11, 12)?*
3. Die letzten beiden Zahlen des **Geburtsjahres** *(z.B. 99, 00, 01, 02, 03, 04)?*
4. Mit welchen **zwei Buchstaben** beginnt der **Name deiner Mutter**?
5. In welcher **Hausnummer** wohnst du *(z.B. 001, 034, 115)?*



genehmigt: KM Bayern III.9-5 O 5106/100/8

(1) Beantworte die folgenden Fragen. <u>Nur eine Antwort ist richtig</u>. Kreuz deshalb nur 1 Antwort an!

Woher bekommen Bienen das Wachs für den Bau ihrer Waben?
☐ Sie sammeln Harz von Bäumen und verarbeiten es zu Wachs.
☐ Sie sammeln es von wachsbildenden Blüten.
☐ Sie sammeln und verwerten Wachs von alten Kerzen**.**
☐ Sie erzeugen es selbst in speziellen Drüsen.

Wie entsteht die charakteristische Form der Bienenwabe?
☐ Beim Bauen der Waben orientieren sich die Bienen am Erdmagnetfeld.
☐ Die Form entsteht durch Hitze aufgrund der Oberflächenspannung von selbst.
☐ Die Bienen orientieren sich beim Bau der Wabe am Stand der Sonne.
☐ Mehrere Bienen arbeiten an einer Wabenzelle, jede stellt eine Wand her.

Welche geometrische Form besitzt die Bienenwabe?
☐ Sie ist viereckig.
☐ sie ist fünfeckig.
☐ sie ist sechseckig.
☐ sie ist rund.

Welchen Vorteil bietet die Bienenwabenstruktur?
☐ Wenig Baustoff bei großem Raumvolumen.
☐ Viel Baustoff bei kleinem Raumvolumen.
☐ Wenig Baustoff bei kleinem Raumvolumen.
☐ Viel Baustoff bei großem Raumvolumen.

Bionik ist…?
☐ die Wissenschaft des Lebendigen.
☐ Technik, die ökologisch produziert wurde.
☐ Technik, die für den Naturschutz verwendet wird.
☐ die Übertragung von Phänomenen der Natur auf die Technik.

Thermoregulation ist…
☐ die Fähigkeit eines Lebewesens die Temperatur fühlen zu können.
☐ die Regel, wie man ein Thermometer ablesen soll.
☐ die Regulation der Körpertemperatur eines Organismus unabhängig von der Außenwelt.
☐ die Fähigkeit eines Organismus, die umliegende Temperatur zu beeinflussen.

Wie könntest Du einem Mitschüler mithilfe der Bienensprache mitteilen, wie weit entfernt sich ein versteckter Schatz befindet?
☐ durch verschiedene Töne, die Du ihm vorsummst.
☐ durch einen Tanz, bei dem Du einen bestimmten Winkel demonstrierst.
☐ durch die Geschwindigkeit einer Bewegung, die Du ihm demonstrierst.
☐ gar nicht, denn Entfernungen können nicht mithilfe der Bienensprache vermittelt werden.

Ein Imker dreht den Bienenstock um 180°, sodass das Einflugloch der Bienen nun im Schatten steht. Wie ändert sich die Tanzrichtung der Bienen?
☐ um 0°.
☐ um 90°.
☐ um 180°.
☐ Die Bienen tanzen gar nicht mehr, da das Einflugloch im Schatten liegt.

Beantworte die folgenden Fragen. **Nur eine Antwort ist richtig**. Kreuz deshalb nur 1 Antwort an!

Ein Bienenstock ist vergleichbar mit einem gleichwarmen Tier. Das bedeutet, dass …
☐ die Außentemperatur gleich der Temperatur im Bienenstock ist.
☐ die Außentemperatur sich der Temperatur im Bienenstock angleicht.
☐ die Temperatur im Bienenstock immer gleich hoch ist.
☐ die Temperatur im Bienenstock immer ca. 21°C ist.

Der 23.08.2013 war ein heißer Tag. Am Stockeingang eines Bienenstocks konnte der Imker einen wesentlich höheren Flugbetrieb der Bienen feststellen als am 23.10.2013, einem eher kühlen Tag, weil…
☐ die Bienen vermehrt Pollen und Nektar sammeln.
☐ die Bienen an heißen Tagen vermehrt Wasser in den Stock tragen.
☐ die Bienen aufgrund der Hitze ihre Flugmuskulatur aktivieren müssen.
☐ Die Bienen den Stock häufig verlassen, um andere Bienen vor der Hitze zu warnen.

Was ist <u>KEINE</u> Folge von zu starker Hitze im Bienenstock?
☐ Die Brut wird geschädigt.
☐ Das Wachs wird weich.
☐ Die Bienen verfallen in eine Wärmestarre.
☐ Der Honig wird ungenießbar.

Was sammeln die Bienen?
☐ Pollen, Nektar, Honigtau.
☐ Pollen, Honig, Nektar.
☐ Wachs, Honig, Zuckerwasser.
☐ Wachs, Pollen, Nektar.

Du möchtest deine Mutter mit einem selbstgemachten Glas Honig überraschen. Wie gehst Du vor?
☐ Du sammelst z. B. Kirschblüten, zerreibst sie und kochst sie in Zuckerwasser.
☐ Du mischst Zucker und Wasser, gibst Honigenzyme hinzu und erhitzt das Ganze auf 37°C.
☐ Du legst Bienenwaben für mindestens 24 Stunden in heißes Wasser.
☐ Honig kann nicht selbst, sondern nur von Bienen hergestellt werden. Deshalb kauft man ihn am besten beim Imker.

Für ein Glas Honig (400ml) müssen Arbeitsbienen…
☐ rund 1.000 mal ausfliegen und dabei einige tausend Blüten besuchen.
☐ rund 10.000 mal ausfliegen und dabei einige hunderttausend Blüten besuchen.
☐ rund 40.000 mal ausfliegen und dabei zwei bis sieben Millionen Blüten besuchen.
☐ rund 400.000 mal ausfliegen und dabei zwanzig bis siebzig Millionen Blüten besuchen.

Wie viel Prozent unserer einheimischen Wild- und Nutzpflanzenarten sind auf die Bestäubung durch die Honigbiene angewiesen?
☐ 10%.
☐ 25%.
☐ 50%.
☐ 80%.

Wenn Du im Spätsommer einen Zwetschgenkuchen auf der Terrasse isst und vom Zucker ein Insekt angelockt wird, ist es <u>KEINE</u>…
☐ Wespe.
☐ Biene.
☐ Ameise.
☐ Fliege.

Beantworte die folgenden Fragen. **Nur eine Antwort ist richtig**. Kreuz deshalb nur 1 Antwort an!

Wie kann der Mensch das Nahrungsangebot für Honigbienen verbessern?
☐ Indem er Wildblumensamen aussät.
☐ Indem er Samen aus dem Regenwald aussät.
☐ Indem er Saatgut, das Pestizide enthält, aussät.
☐ Indem er Samen von immergrünen Pflanzen aussät.

Stichwort Nutztier. Welche Aussage ist wahr?
☐ Die Biene ist für den Menschen wichtiger als das Rind.
☐ Das Huhn ist für den Menschen wichtiger als die Biene.
☐ Die Biene ist für den Menschen wichtiger als das Huhn.
☐ Das Schaf ist für den Menschen wichtiger als die Biene.

Was kann man NICHT aus Bienenprodukten herstellen?
☐ Nahrungsmittel.
☐ Kosmetika.
☐ Medikamente.
☐ Plastik.

Welche Leistung der Biene ist für den Menschen am wichtigsten?
☐ die Herstellung von Honig.
☐ die Bestäubung der Blüten.
☐ die Herstellung von Gelee Royal.
☐ die Herstellung von Propolis.

Was können Balkonbesitzer für Bienen im Sommer tun?
☐ Eine Vogeltränke aufstellen.
☐ Ein altes Vogelhäuschen aufhängen.
☐ Süße Speisen auf dem Balkon stehen lassen.
☐ Tropische und exotische Pflanzen aufstellen.

Was ist in der Regel KEIN Grund für das Sterben von Bienen?
☐ Altersschwäche.
☐ Befall von Parasiten.
☐ Vergiftung durch bestimmte Pflanzenstoffe.
☐ Vergiftung durch bestimmte Pflanzenschutzmittel.

In einigen Regionen Chinas gibt es fast keine Bienen mehr. Was macht die chinesische Bevölkerung um die fehlende Leistung auszugleichen?
☐ Sie halten sich Hummeln, die ihnen Honig liefern.
☐ Sie bestäuben die Blüten per Hand mithilfe von Wattestäbchen.
☐ Sie importieren ihr Obst und Gemüse nur noch aus europäischen und afrikanischen Ländern.
☐ Sie betreiben starke Windmaschinen, sodass der Pollen verbreitet wird.

Pestizide können für die Honigbiene gefährlich sein, weil…
☐ sie das Außenskelett der Bienen zersetzen.
☐ sie das Gedächtnis der Bienen schädigen, was zum Verlust der Orientierungsfähigkeit führen kann.
☐ sie die Augen der Bienen verkleben und sie nichts mehr sehen können.
☐ sie die Beweglichkeit der Flügel einschränken.

Beantworte die folgenden Fragen. **Nur eine Antwort ist richtig**. Kreuz deshalb nur 1 Antwort an!

Wie hat die Politik bereits auf das vermehrte Bienensterben reagiert?

- ☐ Sie hat den Einsatz bestimmter Pestizide eingeschränkt.
- ☐ Sie hat den Import asiatischer Lebensmittel eingeschränkt.
- ☐ Sie hat ein Gesetz verabschiedet, das den Städtebau limitiert.
- ☐ Sie hat eine Richtlinie veröffentlicht, die die Zucht und den Verkauf von Bienenköniginnen regelt.

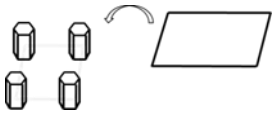
Wie würde es deinen Alltag betreffen, wenn weiterhin so viele Bienenvölker sterben?

- ☐ Es gäbe weniger Pestizide.
- ☐ Es gäbe nur noch wenige Obst- und Gemüsesorten.
- ☐ Es gäbe nur noch wenig Holz.
- ☐ Es gäbe weniger Sauerstoff zum Atmen.

Gedankenexperiment: Du hast die Aufgabe aus einfachen Materialien ohne Schrauben und Nägel einen besonders stabilen Hocker zum Sitzen zu bauen. Wie würdest Du die Aufgabe angehen?

- ☐ 20 Papierbögen zu 20 sechseckigen Röhren falten, aneinander kleben, aufrichten und eine Plastikplatte auflegen.

- ☐ Vier sechseckige Holzstangen (Ø 5 cm) in einem Viereck aufstellen und eine Plastikplatte auflegen.



- ☐ Einen Karton zu einem Sechseck falten, aufrichten und auf das Sechseck eine Plastikplatte legen.

- ☐ Sechs runde Holzstangen (Ø 5 cm) in einem Sechseck aufstellen und eine Plastikplatte auflegen.

(2) Kreuz im Folgenden an, was am ehesten auf Dich zutrifft! Setz bitte **nur 1 Kreuz pro Aussage.**	**stimmt überhaupt nicht**	**stimmt nicht**	**teils, teils**	**stimmt**	**stimmt genau**
Es macht mich traurig, wenn Naturlandschaften bebaut werden.	☐	☐	☐	☐	☐
Die Natur ist immer in der Lage, sich selbst wieder zu erholen.	☐	☐	☐	☐	☐
Schmutziger Rauch aus Fabrikkaminen macht mich wütend.	☐	☐	☐	☐	☐
Wir müssen Wälder roden, damit Getreide angebaut werden kann.	☐	☐	☐	☐	☐
Es ist interessant zu wissen, welche Kreaturen in Teichen und Flüssen leben.	☐	☐	☐	☐	☐
Wir müssen mehr Straßen bauen, damit die Leute aufs Land fahren können.	☐	☐	☐	☐	☐
Man braucht kein Land für den Natur- und Artenschutz vorsehen.	☐	☐	☐	☐	☐
Die Menschen machen sich zu viele Sorgen über die Umweltverschmutzung.	☐	☐	☐	☐	☐
Die stille Natur draußen macht mich ängstlich.	☐	☐	☐	☐	☐
Menschen haben nicht das Recht, die Natur zu ändern, wie sie es für richtig halten.	☐	☐	☐	☐	☐
Am Rande eines Weihers zu sitzen und Libellen zu beobachten ist langweilig.	☐	☐	☐	☐	☐
Menschen sind nicht wichtiger als andere Lebewesen	☐	☐	☐	☐	☐

(3) Denk <u>nur</u> an die heutige <u>Führung am Bienenstock</u>[1] und kreuz im Folgenden an, was am ehesten auf Dich zutrifft. Bitte mach **<u>pro Aussage nur 1 Kreuz</u>**!	**trifft überhaupt nicht zu**	**trifft eher nicht zu**	**teils, teils**	**trifft eher zu**	**trifft völlig zu**
Die Führung am Bienenstock hat mir Freude gemacht.	☐	☐	☐	☐	☐
Ich fand das Thema Honigbiene wichtig.	☐	☐	☐	☐	☐
Ich habe mich gelangweilt.	☐	☐	☐	☐	☐
Ich war mit der Führung am Bienenstock zufrieden.	☐	☐	☐	☐	☐
Ich war mit den Gedanken öfter woanders.	☐	☐	☐	☐	☐
Die Führung am Bienenstock hat mir Spaß gemacht.	☐	☐	☐	☐	☐
Was ich über Honigbienen erfahren habe, bringt mir was.	☐	☐	☐	☐	☐
Ich möchte mehr über Honigbienen erfahren.	☐	☐	☐	☐	☐
Die Führung am Bienenstock war zum Einschlafen.	☐	☐	☐	☐	☐

VIELEN DANK FÜR DEINE MITARBEIT!

[1] Im Fragebogen zur Evaluation des Programms *HOBOS - Das fliegende Klassenzimmer* wurde der Wortlaut “Führung am Bienenstock” mit “das Arbeiten mit der Lernplattform HOBOS” ersetzt.

C Fragebogen zum Computerselbstkonzept

UNIVERSITÄT BAYREUTH

LEHRSTUHL
DIDAKTIK DER BIOLOGIE

Prof. Dr. Franz. X. Bogner

Liebe(r) Student(in),

dieser Fragebogen ist Teil einer wissenschaftlichen Untersuchung.

Der ausgefüllte Fragebogen wird am Ende wieder eingesammelt, **Ihre Leistungen werden dabei aber in keiner Weise bewertet.**

Bitte bearbeiten Sie den Test alleine und bearbeiten Sie die Frage sorgfältig und wahrheitsgemäß! Setzen Sie bitte nur ein Kreuz pro Frage.

Die Daten werden streng vertraulich behandelt und werden nicht an Dritte weitergegeben.

Vielen Dank, dass Sie an dieser Befragung teilnehmen!

Bitte geben Sie Folgendes an:

Datum	□□.□□.□□□□ (tt.mm.jjjj)
Semester	□□ (z.B. 04)
Studiengang	……
Geschlecht	○ weiblich ○ männlich
Geburtsdatum	□□.□□□□ (Monat & Jahr)

(1) Schätzen Sie sich ein: Wie häufig verwenden Sie den Computer für folgende Tätigkeiten: Bitte machen Sie pro Aussage nur 1 Kreuz	**nie**	**weniger als 1x wöchentlich**	**mehrmals pro Woche**	**weniger als 1 Stunde täglich**	**mehrere Stunden täglich**
Surfen im Internet	☐	☐	☐	☐	☐
Elektronische Kommunikation (Internetforen, Email, Skype, ICQ, Facebook Messenger, etc.)	☐	☐	☐	☐	☐
Nutzung von Social Networks	☐	☐	☐	☐	☐
Programmieren	☐	☐	☐	☐	☐
als Hilfsmittel im Studium	☐	☐	☐	☐	☐

(2) Schätzen Sie sich auch hier selbst ein, wie gut Sie folgende Tätigkeiten beherrschen: Bitte machen Sie pro Aussage nur 1 Kreuz	**überhaupt nicht gut**	**einigermaßen gut**	**gut**	**sehr gut**
Umgang mit dem Computer allgemein	☐	☐	☐	☐
Erstellen von Texten	☐	☐	☐	☐
Erstellen von Grafiken	☐	☐	☐	☐
Programmieren	☐	☐	☐	☐
Nutzung des Internets	☐	☐	☐	☐
Computerspiele	☐	☐	☐	☐
Beheben von Störungen/Fehlermeldungen/technischen Defekten	☐	☐	☐	☐
Software (Sicherer Umgang mit Dateiformaten, Softwareinstallationen, Downloads, etc.)	☐	☐	☐	☐
Hardware (Erweiterung des Speicherplatzes, Austausch verschiedener Bauteile, etc.)	☐	☐	☐	☐

(3) Kreuzen Sie im Folgenden bitte an, was am ehesten auf Sie zutrifft. Bitte machen Sie pro Aussage nur 1 Kreuz	**trifft überhaupt nicht zu**	**trifft eher nicht zu**	**trifft eher zu**	**trifft völlig zu**
Es ist mir sehr wichtig mit dem Computer zu arbeiten.	☐	☐	☐	☐
Am Computer zu spielen oder zu arbeiten macht mir richtig Spaß.	☐	☐	☐	☐
Ich benutze den Computer, weil mich das sehr interessiert.	☐	☐	☐	☐
Die Beschäftigung mit Computerprogrammen ist mir sehr wichtig.	☐	☐	☐	☐
Gute Computerkenntnisse sind für mein Weiterkommen in der Schule wichtig.	☐	☐	☐	☐
Wenn ich am Computer arbeite, merke ich oft nicht, wie die Zeit vergeht.	☐	☐	☐	☐
Für die Beschäftigung mit dem Computer verzichte ich gerne auf andere Aktivitäten.	☐	☐	☐	☐
Im Umgang mit Computern stelle ich mich sehr geschickt an.	☐	☐	☐	☐
Man kann mich schon als Computer-Crack bezeichnen.	☐	☐	☐	☐
Wenn ich ein neues Computerprogramm erlernen muss, fühle ich mich schnell überfordert.	☐	☐	☐	☐
Ich setze mich eigentlich nur dann an den Computer, wenn es sich gar nicht anders vermeiden lässt.	☐	☐	☐	☐

(Eidesstattliche) Versicherungen und Erklärungen

(§ 5 Nr. 4 PromO)

Hiermit erkläre ich, dass keine Tatsachen vorliegen, die mich nach den gesetzlichen Bestimmungen über die Führung akademischer Grade zur Führung eines Doktorgrades unwürdig erscheinen lassen.

(§ 8 S. 2 Nr. 5 PromO)

Hiermit erkläre ich mich damit einverstanden, dass die elektronische Fassung meiner Dissertation unter Wahrung meiner Urheberrechte und des Datenschutzes einer gesonderten Überprüfung hinsichtlich der eigenständigen Anfertigung der Dissertation unterzogen werden kann.

(§ 8 S. 2 Nr. 7 PromO)

Hiermit erkläre ich eidesstattlich, dass ich die Dissertation selbständig verfasst und keine anderen als die von mir angegebenen Quellen und Hilfsmittel benutzt habe.

(§ 8 S. 2 Nr. 8 PromO)

Ich habe die Dissertation nicht bereits zur Erlangung eines akademischen Grades anderweitig eingereicht und habe auch nicht bereits diese oder eine gleichartige Doktorprüfung endgültig nicht bestanden.

(§ 8 S. 2 Nr. 9 PromO)

Hiermit erkläre ich, dass ich keine Hilfe von gewerbliche Promotionsberatern bzw. -vermittlern in Anspruch genommen habe und auch künftig nicht nehmen werde.

Bayreuth, den ……..... ……..

Datum Unterschrift

Danksagung

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