

Perspective

Sustaining insect biodiversity through *Action Competence* — An educational framework for transformational changePeter Lampert^{a,*}, Dave Goulson^b, Daniel Olsson^a, John Piccolo^a, Niklas Gericke^a^a Department of Environmental and Life Sciences, The Faculty of Health, Science and Technology, Karlstad University, Universitetsgatan 2, 651 88 Karlstad, Sweden^b School of Life Sciences, University of Sussex, Brighton BN1 9RH, United Kingdom

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ABSTRACT

Insect decline, i.e. the rapid loss of insect biodiversity and species abundance, is an imminent crisis that mirrors the global loss of biodiversity and biological annihilation. Conservation scientists have therefore called for effective public education on how to mitigate insect decline. In this paper, we develop the framework “*Action Competence for Insect Conservation (ACIC)*” as a tool for improving education and citizen action for insect biodiversity conservation. The ACIC is an educational framework to develop peoples’ abilities to take actions that sustain insect biodiversity, connecting insect conservation science with social science. This framework is applicable in various contexts and settings in both formal (e.g. schools, universities) and informal (e.g. outreach) education. It can be used to design and improve educational approaches, develop social interventions for insect conservation more generally, and develop instruments to assess such interventions. ACIC builds on the educational concept of *Action Competence* that goes beyond traditional education, which has focused on theoretical knowledge. Instead, the ACIC aims to foster peoples’ action-oriented knowledge, confidence in their actions and willingness to take action. This explicit focus on actions contributes to overcoming gaps between knowledge and action implementation. The ACIC covers not only actions in private greenspaces, but also highlights the importance of actions that address other people in the community along with relevant stakeholders. We believe that the ACIC framework can contribute to identifying and developing effective intervention approaches, which have the potential to support transformational change in sustaining insect biodiversity.

1. Introduction

The current decline of insects is a highly relevant environmental problem (Hallmann et al., 2017; Sánchez-Bayo and Wyckhuys, 2019; Van Klink et al., 2020; Wagner et al., 2021). The ongoing insect declines and missed targets for biodiversity conservation (Buchanan et al., 2020) show that there is a lack of sufficient effective actions to sustain insect biodiversity. Hence, conservation scientists identify an urgent need to educate a broader public to take action (Cardoso et al., 2020; Harvey et al., 2020; Luke et al., 2023). However, traditional education focusing on raising knowledge and awareness is often ineffective and barely leads to changes in conservation behaviour (Marselle et al., 2021). We therefore need a transformation of education to support learners effectively in taking actions. In this paper, we propose the first theoretically grounded educational framework focusing on peoples’ competences to take actions for sustaining insect biodiversity. This framework – “Action

Competence for Insect Conservation” (ACIC) provides guidance for educators to identify and foster peoples’ individual abilities to take positive actions for insects.

The ACIC framework builds on the concept of *Action Competence* that was applied in various educational contexts, such as environmental education (Breiting et al., 2009; Jensen and Schnack, 1997) and education for sustainability (Boeve-de Pauw et al., 2015; Olsson et al., 2020; Sass et al., 2020; Sinakou et al., 2019). Education based on action competence proved to positively affect primary and secondary school students’ skills and inclination to contribute to solving environmental problems (Breiting et al., 2009), and it can lead to higher levels of self-reported sustainability behaviour (Boeve-de Pauw et al., 2015). Action competence goes beyond traditional knowledge-centred educational approaches, focusing instead on peoples’ competences to take action. The presented ACIC framework connects research in insect conservation biology with research in social science with a focus on education. The

* Corresponding author at: Karlstad University, Universitetsgatan 2, 651 88 Karlstad, Sweden.

E-mail addresses: peter.lampert@kau.se (P. Lampert), D.Goulson@sussex.ac.uk (D. Goulson), daniel.olsson@kau.se (D. Olsson), john.piccolo@kau.se (J. Piccolo), niklas.gericke@kau.se (N. Gericke).

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framework can be used to design educational approaches contributing to a society that is more competent and willing to take actions for insect conservation. Finally, the ACIC framework provides a theoretical basis for social and educational research in the field, which is currently underexplored.

Therefore, this paper addresses conservation scientists and other biologists interested in communicating about insect declines and conservation, educators in the field of science and environmental education, and social and educational scientists. This paper consists of six sections. The first section provides an overview of the problem of insect decline. The second section outlines the importance of social research in this context. The third section introduces the educational concept of Action Competence as an action-oriented ideal to educate about environmental challenges. The fourth section focuses on the idea of direct and indirect actions as central elements of the framework. The fifth section provides details of the ACIC framework, including the three dimensions of knowledge, confidence, and willingness. The final sixth section highlights benefits and potential applications of the new framework.

2. The problem of insect decline

Several studies from the last decade show that insect declines are rapid, long-term and ongoing, although there are huge knowledge gaps (Hallmann et al., 2017; Sánchez-Bayo and Wyckhuys, 2019; Van Klink et al., 2020). One long-term study from Germany showed an alarming decline of flying insects' biomass of 75 % in less than 30 years (Hallmann et al., 2017). The observed insect declines are problematic, because insects comprise about 70 % of known species, and they are crucial for the functioning of most terrestrial and freshwater ecosystems. Since insects are also important prey for many animals, insect declines can link to declines in higher trophic levels (Bowler et al., 2019). Due to the close relationship between pollinators and plants, parallel declines of insect-pollinated plants are observable (Biesmeijer et al., 2006). The decline of insects connects most directly to humans via pollination, because insects pollinate around 75 % of all crop species (Klein et al., 2007).

However, insect declines are complex and it is necessary to avoid generalizations and consider knowledge gaps (Wagner et al., 2021). Particularly, we lack time series data for many insect groups and geographical regions (Harvey et al., 2020). Therefore, it is not valid to generalize the problem to "all insects are declining everywhere", because some insect groups and geographical regions are less affected from declines, and a few insects are increasing (Van Klink et al., 2020). Large-scale time series data are unfortunately not available for most geographical regions. Even though the knowledge base on insect declines and its drivers is incomplete, we have enough information indicating that we must act now to avoid further declines (Cardoso et al., 2020; Harvey et al., 2020).

To halt insect decline, it is necessary to identify and address its drivers. Research shows that it is not a single driver causing the declines, but a complex interplay of anthropogenic drivers (Goulson, 2021; Wagner et al., 2021). The main drivers are habitat loss and fragmentation due to intensive agriculture, deforestation and urbanization, pesticide use, climate change, spread of parasites and diseases, pollution, and invasive species (Habel et al., 2019; Wagner et al., 2021). What all drivers have in common is that they relate to human actions, therefore solutions will require human actions to stop insect declines.

The implementation of policies to conserve insects proves difficult to enforce (Marselle et al., 2021), despite various national and international initiatives. Insect decline mirrors the larger crisis of biodiversity loss in general, which is a "wicked problem" (Sharman and Mlambo, 2012). Wicked problems are complex, not fully understood, involve many stakeholders with different perspectives and conflicting interests (Balint et al., 2011). Solving wicked problems is difficult, because there are no easy available solutions, and no "correct" or "best" solutions. Instead, we need to find unprecedented solutions (Sharman and

Mlambo, 2012). Solutions for wicked problems need to take the personal social perspectives into account, such as persons experiences, actions, norms, and values (Balint et al., 2011). This is in line with Cardoso et al. (2011) who highlighted the importance of the social perspectives to involve a broader public and to overcome peoples lack of awareness of the importance of insects.

The ACIC framework presented in this paper shall answer these calls for more action and contribute to solving the wicked problem by a new educational ideal that considers the necessary personal social dimension. Social scientific perspectives could help to identify personal obstacles to take action and they could guide the way to more effective approaches and policies.

3. The importance of social perspectives

Connecting conservation and social science has the potential to develop more holistic and transdisciplinary approaches to insect conservation and it can help to overcome implementation gaps (Toomey et al., 2017). Much research on insect declines and conservation was done in the last decades. However, social research around these conservation issues remains underexplored (Hall and Martins, 2020; Knapp et al., 2021). This existing lack of social research is problematic, because an integration of social and ecological understandings is crucial to evoke changes in human and societal actions on insect conservation (Hall and Martins, 2020).

One important strand of social research is insect conservation psychology that explores the relationship between humans and insects (Samways, 2018). Insect conservation psychology assumes that fearing insects is intrinsic, whereas loving insects needs to be learnt through positive interactions (Samways, 2018). Peoples' lack of knowledge about diversity and importance of insects goes along with a limited ability to distinguish the small number of insect "pests" from the much larger number of harmless or beneficial insect species, leading to more negative attitudes towards insects (Fukano and Soga, 2021). People living in urban areas have few interactions with nature, with the consequence that people in urban areas have particularly negative attitudes towards insects (Fukano and Soga, 2021). Ongoing urbanization could therefore lead to a society in which most people have little interactions with nature, but where negative attitudes towards insects are widespread.

Social perceptions, such as attitudes, emotions or nature connectedness are important for taking concrete actions for insect conservation. A diversity of interactions with nature and positive emotions such as fascination and joy are relevant predictors for peoples' pro-pollinator behaviour (Knapp et al., 2021; Sturm et al., 2021). An active engagement with and care for nature can have positive effects on peoples nature connectedness, their knowledge and attitudes, whereas negative attitudes and the connected biophobia can lead to a reduced motivation to protect wild animals including insects (Samways, 2018; Soga et al., 2020). Another important obstacle to taking actions are conflicting social norms, such as norms around tidiness or lawn management, that hinder people from creating insect-friendly but "untidy" greenspaces (Burr et al., 2018; Knapp et al., 2021).

We now focus on existing educational perspectives relevant for the framework development. Recent educational studies show that knowledge about insect diversity is low (Shipley and Bixler, 2017). Moreover, various insect groups are underrepresented in biology textbooks and the percentage of pages dedicated to insects declined drastically in the last decades (Gangwani and Landin, 2018). Studies show a bias towards honeybees (*Apis mellifera*) in teaching approaches and textbooks for pollination and pollinator conservation (Schönfelder and Bogner, 2018; Sieg et al., 2018). This underrepresentation of insect biodiversity in educational materials and approaches is problematic, since it might not be clear for students why insect diversity is important.

Despite the high current relevance and many ongoing conservation initiatives, few educational studies focused specifically on conservation.

One study reports that university students have a limited knowledge of insect pollinator conservation actions (Golick et al., 2018). Another study on students' attitudes towards honeybees shows that attitudes can change through educational interventions and highlights the importance of reducing fear to foster pro-conservation attitudes towards honeybees (Schönfelder and Bogner, 2018). A further study shows that an interplay of many interrelated factors (attitudes, knowledge, interest, fear, learning enjoyment) influences pro-environmental behaviour intentions and that interventions can positively affect these factors (Sieg and Dreesmann, 2021). A final recent study shows that taking part in pollinator conservation activities can lead to excitement, fascination, and empathy (Ruck and Mannion, 2021).

These educational studies underline both the relevance and the complexity of education in this field. One limitation of the mentioned studies is that they focus only on pollinators, sometimes on specific groups of pollinators such as honeybees (Schönfelder and Bogner, 2018) or bumblebees (Sieg and Dreesmann, 2021). Education on sustaining insect biodiversity needs to consider the many other groups of insects as well, not only those that are evidently important for humans. It is not only the instrumental value of insects that counts, but also their intrinsic natural value is a sufficient reason for conservation (Piccolo et al., 2022). Another limitation of existing studies is that they do not provide insights into changes in the learners' competences to take concrete actions for conservation.

We therefore need more educational research considering insect diversity and focusing on learners' competences to take positive actions for insects. Education needs to go beyond traditional teaching focusing mainly on transferring knowledge, because knowledge about environmental issues alone rarely leads to the intended behavioural changes (Jensen and Schnack, 1997). This gap between knowledge about a problem and actual behaviour is well documented for pro-environmental actions in general (Kollmuss and Agyeman, 2002) and recently shown for pro-pollinator actions as well (Knapp et al., 2021). We view *Action Competence* as a promising way forward to develop action-oriented educational interventions and research contributing to solve the wicked problem of insect decline.

4. Actions and Action Competence

The concept of *Action Competence* provides a potential solution to approach wicked problems as research from environmental and sustainability education ranging from primary school to upper secondary school shows (Boeve-de Pauw et al., 2015; Breiting et al., 2009; Jensen and Schnack, 1997; Olsson et al., 2022; Sass et al., 2020; Sinakou et al., 2019). In a general sense, action competence describes peoples' ability to act towards solving such controversial problems, when it is necessary to take decisions based on critical thinking and incomplete knowledge (Jensen and Schnack, 1997; Sass et al., 2020; Varela-Losada et al., 2016). Action competence can be interpreted as a generic competence of people that can be fostered through education (Sass et al., 2020). Sass et al. (2020) define an action competent person as follows: "someone who is committed and passionate about solving a societal issue, has the relevant knowledge about the issue at stake as well as about the democratic processes involved, takes a critical but positive stance toward different ways for solving it, and has confidence in their own skills and capacities for changing the conditions for the better" (Sass et al., 2020, p. 303). In short, action competence not only includes the dimension of individual knowledge, but also considers the dimensions of willingness to act and confidence in one's own actions (Fig. 1).

Central for the AC concept is the term *action*; action refers to a specific type of behaviour, which fulfils two main criteria. First, an action is deliberate and intentional – the person decides which actions to take and how to take those actions. Second, an action is targeted at solving a problem. In this sense, actions go beyond activities that do not necessarily try to solve a problem (Jensen and Schnack, 1997). We can differentiate two main types of actions, namely *direct actions* and *indirect*



Fig. 1. The Action Competence framework for sustainable development. (After Sass et al. (2020)).

actions (Jensen, 2002; Jensen and Schnack, 1997; Sass et al., 2020). Direct actions contribute directly to solving an environmental problem; whereas indirect actions attempt to influence others to contribute to solving the problem (see Section 5). Both types of actions can take place on an individual level, e.g. when a person changes their own lifestyle, or on a collective level, when a group of people takes actions together (Jensen, 2002; Jensen and Schnack, 1997).

Actions also go beyond mere behaviour, because behaviour could be copied without understanding or a person could be pushed to a specific behaviour. Therefore, behaviour modification and action competence are two fundamentally different goals in environmental education (Jensen and Schnack, 1997). Instead of trying to force behaviour on people, the aim of an education based on action competence is to give learners the chance to foster their individual competences in a democratic way (Mogenssen and Schnack, 2010; Sass et al., 2020). Hence, it is not the aim to promote a single type of behaviour that is always right, but to enable learners to take appropriate positive actions depending on the context.

The concept of action competence fits well to the issue of halting insect declines as a highly relevant societal issue. However, it is necessary to specify and apply this generic action competence concept for the concrete context of insect decline and insect conservation to provide sufficient information and guidance for education and research. The following section outlines how the general idea of action competence was applied to build the framework of "Action Competence for Insect Conservation" (ACIC).

5. Framework development and outline of ACIC

5.1. Defining actions for ACIC — direct and indirect actions

The ACIC framework is based on the general definition of action competence provided by Sass et al. (2020), with the two main types of actions – direct actions and indirect actions. Therefore, a first central element of the framework is to define an action in the context of ACIC. All actions included in the ACIC must fulfill the criterion that they *aim to solve a problem* (see Section 4). In addition, actions must be deliberate and intentional. Applying the two types of direct and indirect actions to the context of insect conservation leads to the following two definitions.

A direct action is a deliberate behaviour that aims to sustain insect biodiversity in the personal environment. An indirect action is a deliberate behaviour that encourages others to sustain insect biodiversity. An example for a direct action is creating good habitats for insects in one's garden. An example for an indirect action is informing other people about the issue of insect decline so that these people take actions.

Including both direct and indirect actions in the ACIC framework is not about trying to differentiate between what is direct and what is indirect in every situation, rather it is about considering the full picture of the problem and using the full repertoire of solutions for actions and for learning from actions. Both types of actions can be interrelated in the sense that an indirect action (e.g. motivating others to let their lawns grow) can lead to a direct action (e.g. another person takes up this idea and cuts the lawn less often). It is also possible that actions serve both direct and indirect purposes (e.g. an uncut lawn that directly supports insects serves as an inspiring example for others).

Direct actions of ordinary citizens in greenspaces can contribute to create stepping-stone habitats in urbanized areas (Hall et al., 2017; Proske et al., 2022), mitigating the impact of urbanization. Researchers concluded that even heavily urbanized areas can serve as refuges for insects and put relevant insect conservation within reach (Hall et al., 2017). In addition to public green spaces, private gardens can provide benefits for insect diversity and contribute to conservation (Gerner and Sargent, 2022; Goddard et al., 2010). These gardens can make up a considerable proportion of cities – estimates are around 16 % in Stockholm (Sweden) and 22–27 % in cities in the UK (Goddard et al., 2010). Successful direct actions (e.g. attracting insects to private greenspaces) can also be beneficial for the person taking the action from an insect conservation psychology perspective and lead to further actions (Samways, 2018). Finally, attracting insects through direct actions facilitates positive experiences with insects, which can counteract common negative attitudes towards insects hindering conservation engagement (Fukano and Soga, 2021; Soga et al., 2020).

However, we also need indirect actions that encourage other people, particularly relevant stakeholders (farmers, politicians, companies, NGOs), to take further actions that support insect diversity (Harvey et al., 2020). These indirect actions, such as consumer behaviour, education, social and political engagement, informing and motivating others (Kawahara et al., 2021), allow tackling bigger drivers of the problem of insect decline which cannot be tackled by direct actions in a garden. This is also an issue of considering the full picture of the problem, and not transmitting an oversimplified solution. The importance of indirect actions is however not sufficiently included in traditional pro-environmental behaviour models (Jensen, 2002). The impact of indirect actions can be illustrated by the school strikes for climate that also led to other indirect actions (e.g. addressing politicians), and eventually led to a global movement and manifold direct actions connected to climate change mitigation.

5.2. Action recommendations in existing initiatives and scientific papers

Based on this starting point that both direct and indirect actions are

relevant to mitigate insect declines, we analysed two types of sources to derive their action recommendations for ordinary citizens. We analysed a) a selection of eight existing insect (pollinator) conservation initiatives¹ ranging from the national level (Sweden, Ireland, UK) to the international level (Europe, North America) and b) a selection of eight recent scientific papers (Barbett et al., 2020; Harvey et al., 2020; Kawahara et al., 2021; Knapp et al., 2021; Sharma et al., 2019; Sturm et al., 2021; Wagner et al., 2021) focusing on insect decline and conservation. This analysis supported the theoretical and empirical grounding of the ACIC framework.

The analysis showed that many action recommendations for citizens focus on direct actions in personal greenspaces that help to mitigate the negative effects of the driver of urbanization. However, few initiatives/papers provide sufficient recommendations for citizens to enable them to take indirect actions, such as addressing the crucial factor of intensive large-scale agriculture or addressing relevant social perspectives. The existing recommendations in initiatives differ considerably in the number of actions suggested and how these actions are structured, which could make it difficult for educators to decide what and how to teach. Based on this analysis, the list of actions in Table 1 assigns common actions recommended for ordinary citizens as being direct or indirect actions. Additionally, we highlighted the different aims of these actions.

Table 1 describes direct and indirect actions for citizens in general to take to sustain insect biodiversity, not actions to be taken by individuals in their roles as professionals within business and organizations, which is also important. In particular, it is important that farmers, politicians, entrepreneurs, scientists, organizations, and other stakeholders take action as well. Even though it is not the primary focus of the ACIC framework, the idea of direct and indirect actions can be applied for these professional roles as well. For instance, direct actions of farmers (e.g. avoiding harmful pesticides or planting hedgerows) or indirect actions of farmers (e.g. convincing other farmers) can have a large impact. For politicians, indirect actions can be powerful (e.g. provide legislation, funding, and management structures), and direct actions in own greenspaces can underline their engagement.

6. Knowledge, confidence and willingness in ACIC

The ACIC framework aims to go beyond transmitting only theoretical knowledge about direct and indirect actions. Instead, the framework builds on the three interrelated dimensions of a) action-oriented knowledge, b) the confidence in one's actions, and c) the willingness to take these actions (Sass et al., 2020). This section explores these three dimensions and connects all aspects from the prior sections.

6.1. The knowledge dimension in ACIC

Knowledge that should build up ACIC needs to be *action-oriented* and not only theoretical (Jensen, 2002). In general, this action-oriented knowledge should be coherent (Jensen and Schnack, 1997), but open to new knowledge or insights (Almers, 2013). Educators and learners

¹ Initiatives analysed: We have analysed the following eight initiatives on insect/pollinator conservation. All online-sources were latest accessed on the 7.12.2022. EU Pollinators initiative: https://wikis.ec.europa.eu/display/EUPKH/Citizens?preview=/25559573/28869041/Citizens%20engagement+Factsheet_A4_1007.pdf Pollinator Partnership: <https://www.pollinator.org/7thingsXerces+society> society: <https://xerces.org/bring-back-the-pollinatorsX-Pollination>: <https://xpollination.org/Naturvårdsverket>: <https://www.naturvardsverket.se/amnesomraden/pollinering#E102812064> Pollinera Sverige (SURR I Skolan): [https://pollinerasverige.se/category/kunskapsmaterial/Operation+Radda+Bina+\(Naturskyddsföreningen\)](https://pollinerasverige.se/category/kunskapsmaterial/Operation+Radda+Bina+(Naturskyddsföreningen)): <https://www.naturskyddsforeningen.se/kampa-nj/radda-bina/All-Ireland+Pollinator+plan>: <https://pollinators.ie/wp-content/uploads/2018/05/Pollinator-Plan-2018-WEB.pdf>.

Table 1

Direct actions and indirect actions for citizens for sustaining insect biodiversity according to the ACIC-framework.

Actions for ACIC	
Direct actions: A direct action is a deliberate behaviour that aims to sustain insect biodiversity in the personal environment.	Indirect actions: An indirect action is a deliberate behaviour that contributes to others sustaining insect biodiversity.
Actions in personal spaces (garden, lawn, balcony, windowsill) that improve habitats for insect diversity at home/school/university/workplace Aim: Actions address the driver of urbanization Concrete examples: <ul style="list-style-type: none"> • Reduce disturbance – mow lawns less frequently, leave “wild” areas • Provide a diversity of flowering plants throughout the season (flowers, shrubs, trees) • Plant pollinator friendly plants, but avoid invasive species • Reduce/Avoid pesticides and herbicides – Practice integrated pest management • Provide nesting sites for different types of insects (e.g. bare soil, dead wood or leaves, small “bee hotels”, high grass...) • Provide habitat and food for the larval stages (e.g. hostplants for caterpillars; water basins, dead wood...) • Use low impact lighting • Support and appreciate insect diversity instead of unspecified killing of insects (avoid “bug zappers”) 	Actions connected to critical customer behaviour Aim: Actions address the driver of large scale agriculture and forestry, and economical aspects connected to this driver Concrete examples: <ul style="list-style-type: none"> • Buy/demand organic products and products from small scale and seasonal production Actions that address other people in the personal community or on a larger community level Aim: Actions address indirect drivers of personal perspectives; Actions enable and support others to take further direct/indirect actions Concrete examples: <ul style="list-style-type: none"> • Inform other people about the importance of insects, about the problem of insect decline and about actions to sustain insect biodiversity • Show personal engagement • Promote positive attitudes towards insects and insect-friendly actions • Ask and support others to take actions • Support and engage in environmentally friendly politics • Support and engage in environmental organizations, initiatives, or NGOs Actions that contribute to scientific progress Aim: Actions address the problem of scientific gaps Concrete examples: <ul style="list-style-type: none"> • Engage as a citizen scientist • Support scientific organizations

should be aware that we always take decisions and actions based on incomplete knowledge (Almers, 2013), when dealing with wicked problems. Researchers in the field of action competence identified four relevant aspects of knowledge: Knowledge about a) the effects of the problem b) the causes of the problem c) possibilities and strategies to change d) a vision for the future (Jensen, 2002; Sass et al., 2020). Education focusing primarily on the negative effects of the problem can lead to worry, weakening commitment, or even paralysis. Therefore, it is important to consider all four aspects to equip learners with concrete tools and a future vision to deal with the problem (Jensen, 2002).

a) The first aspect is **knowledge about effects** of insect decline so that learners see the significance and actuality of the issue (see Section 2). This knowledge should include both effects on humans, and effects on ecosystems in general (Cardoso et al., 2020). Hence, it is central to provide knowledge about the diversity and the different functional groups of insects (pollinators, decomposers, insects as prey and predators) (Kawahara et al., 2021). Since insect decline is a “wicked problem”, the knowledge should consider the complexity of the

problem and avoid oversimplifications leading to wrong conclusions (Sharman and Mlambo, 2012). In particular, it is important to make explicit the difference between conservation of domesticated species (e.g. honeybees) and conservation of a diversity of wild insects (Geldmann and González-Varo, 2018). The gaps in our knowledge should be included as well, such as missing data or unknown long-term effects of decline.

- b) The second aspect is **knowledge about the causes** of the problem, since this is crucial to develop targeted actions. A behaviour without knowing how it mitigates the root causes of a problem, cannot be considered as an action, because it is not targeted and not understood (see Section 3) (Jensen and Schnack, 1997; Sass et al., 2020). Hence, this includes the knowledge of the direct drivers of insect decline, such as habitat loss and fragmentation, pesticide use, parasites and diseases, or climate change (see Section 2). We also identified social perspectives (negative attitudes, conflicting social norms and values) as indirect drivers of the problem (see Section 3). This knowledge is required so that learners can develop a (self-) critical stance. It is also important to identify context specific causes (local drivers, stakeholders involved) which should be addressed primarily to achieve a high impact of actions.
- c) The third aspect is **knowledge about strategies for change** to provide learners with a repertoire of potential actions. This knowledge should focus on the idea of self-determined and targeted actions following the idea of action competence (see Section 4). Knowledge about actions should include both direct actions and indirect actions addressing the societal level, since both are relevant and necessary to tackle the issue of insect decline. Table 1 provides an overview of common potential actions for ordinary citizens as a starting point for education. More in-depth knowledge about strategies for change and potential actions can be derived from the papers used for the ACIC development (see Section 5.2.), other comprising recommendations on insect conservation (Samways et al., 2020), or the conservation evidence platform (www.conservationevidence.com). This knowledge needs to be applied to the context (e.g. which drivers need to be addressed specifically) and the personal situation, since every individual has specific possibilities to take various direct and indirect actions.
- d) The fourth dimension is **knowledge about alternatives and visions**, providing a positive outlook “where we want to go”, which gives a direction for actions. This vision could include a positive stance towards insect diversity in society and politics, or social norms that appreciate biodiversity rich green spaces and challenge established norms (Habel et al., 2019; Harvey et al., 2020; Samways et al., 2020). It is important to challenge negative “visions” people have, namely that taking actions to sustain insect biodiversity leads to more “pests” in their environment. A first argument to challenge this vision is that most insect species are harmless and beneficial. Another argument comes from a recent meta-analysis showing that it is manicured lawns that disproportionately favour the abundance of “pest” species, whereas reducing the mowing frequency in urban greenspaces benefits the diversity of many harmless and beneficial insects (Proske et al., 2022). In general, a positive vision shows an achievable and desirable future that sustains insect biodiversity and positively affects personal wellbeing (Samways, 2018).

6.2. The confidence component in ACIC

The confidence component consists of two interrelated parts; the confidence in one's own skills and capabilities for change, and the confidence that one's own actions are relevant (Sass et al., 2020). Learners need to develop confidence that they are able to apply knowledge and skills successfully (Chawla, 2009). Hence, it is necessary that learners get the chance to take actions in the real world. This builds on the idea of action-orientation knowledge (Jensen, 2002) discussed above. By taking actions, learners can experience mastery and develop a

personal sense of efficacy (Chawla, 2009). As Chawla and Derr (2012) put it, learners need the possibility to “learn about, through, and from actions”. Therefore, learners should get the chance to learn the relevant knowledge dimensions to take direct and/or indirect actions (see Table 1), decide themselves on actions to take, take these actions in the real world, and finally reflect on the actions and their outcomes.

By taking real world action and reflecting on them, learners get the chance to experience the desirable outcomes that their actions produce. This contributes to confidence in effecting change (Sass et al., 2020). It is also possible, that people plan and take actions in groups, which can contribute that they feel more capable of finding solutions to the issue at stake. Such collaborative actions provide the opportunity to approach problems like insect decline from a broader and more diverse perspective, and different competences of individuals can complete each other (Sass et al., 2020). It is critical to reflect with learners on these actions (Sinakou et al., 2019) to build up an understanding how their actions contribute to insect conservation. Citizen science focusing on insect observations is a potential way to make the outcomes of direct actions visible, when learners get the opportunity to track which insects they attract through their actions (Sharma et al., 2019).

6.3. The willingness dimension in ACIC

The final dimension of ACIC relates to the willingness to take actions. Willingness is particularly important to overcome obstacles or to persevere after disappointments (Jensen and Schnack, 1997). Therefore, the confidence gained through successful actions directly relates to the willingness and can contribute to a continuation of actions (Sinakou et al., 2019). Willingness is something that people develop individually, and the motivation to take action should come from within (Jensen and Schnack, 1997; Sass et al., 2020). Educators cannot and should not try to force ‘willingness’ upon learners. However, we can derive some conclusions from the social perspectives (see Section 3) and action competence (see Section 4) related to willingness to take actions for insect conservation.

Willingness consists of commitment and passion to contribute to action (Sass et al., 2020). The commitment is based on personal intent, goals and the identification with these goals. Applied to insect conservation, this means that it is important that learners identify themselves with a vision of a future that supports insect diversity or create their own vision of such a future and that learners find the issue personally relevant (see aspects a) and d) in the knowledge section). The personal intent is both related to the fear of negative consequences of insect decline and to positive motivations, such as the wish to take care of the environment and its organisms (Samways, 2018). We can also consider emotions, attitudes, and interest as relevant for the development of willingness for pro-environmental actions (Sieg and Dreesmann, 2021). Positive emotions, such as fascination and joy, can have a positive effect on pro-pollinator behaviour (Knapp et al., 2021; Sturm et al., 2021) and hence support the willingness to take actions, whereas negative attitudes and biophobia could have a negative effect (Samways, 2018; Soga et al., 2020).

The possibility to take deliberate actions is also crucial for the development of willingness, so it is important not to force behaviors on the learners. Only contexts that promote autonomy lead to the development of the type of passion that supports people to engage and persist (Vallerand, 2008). An active engagement and care for nature can have positive effects on learner's nature connectedness, their knowledge and attitudes (Soga et al., 2016). Additionally, direct action experiences in nature with insects can lead to a higher knowledge about insects and reduce negative attitudes towards insects (Fukano and Soga, 2021). This is in line with the reported positive effects of pollinator conservation activities on excitement, fascination, and empathy (Ruck and Mannion, 2021). Successful actions can also positively affect the personal well-being (Samways, 2018) and hence support the motivation to take further actions.

6.4. Integrating all aspects into the ACIC framework

Taking the findings from all five sections together, we can give a definition of Action Competence for Insect Conservation (ACIC). “A person who is action competent in the context of insect conservation, (i) knows about actions to sustain insect biodiversity and the relevance of these actions, (ii) has confidence in their own skills and capabilities to take real actions, and (iii) is willing to take these actions. These actions include both direct actions in the personal environment, and indirect actions encouraging others to sustain insect biodiversity.” Fig. 2 shows a graphical summary of the ACIC framework. In the following final section, we will provide more details on the use of ACIC.

7. Summary and final conclusion

The ACIC framework is the first to apply the concept of action competence to the issue of insect decline and conservation of insect biodiversity. The framework promotes education that answers the critique on ineffective traditional educational approaches that focus on theoretical knowledge and have limited effects on peoples' pollinator conservation behaviour (Marselle et al., 2021). The ACIC framework builds a theoretical and empirical grounded foundation for such an education to sustain insect biodiversity, considering the broad variety of potential direct and indirect actions.

The ACIC framework is applicable for many contexts because it is comprehensive, open, and simple to use. It is comprehensive since every action can be classified as direct or indirect or, in some cases, actions serve as both. It is open in the sense that it allows the inclusion of new scientific findings, context specific foci, or further levels of detail. Table 1 is not a complete list of action recommendations, but rather a starting point for taking actions, since it is necessary to adapt the actions to the geographical and personal context. The ACIC framework can also be utilized by relevant stakeholders (farmers, politicians, organizations, entrepreneurs, scientists, ...) who have the potential to take a variety of impactful actions in their roles as professionals. Finally, the ACIC framework is simple to use because it consists of just two easy understandable categories of actions in contrast to other recommendations with more complex structures. This simplicity shall inspire educators and learners to think about possibilities for direct and indirect actions in their context, without overwhelming them.

The value of both direct and indirect actions depends on the context (e.g. persons' abilities, profession, possibilities, natural conditions, local contexts). In particular, planning actions should first identify which drivers of insect decline are the most relevant in a given context and how to address these drivers most effectively through direct and/or indirect actions. Moreover, the value of direct and indirect actions can be evaluated both from an environmental perspective and from an environmental educational perspective. From an environmental perspective, the value depends on how an action contributes to sustaining insect biodiversity. From an environmental educational perspective, the value of an action depends on how this action contributes to development of action competence (Jensen and Schnack, 1997). Ideally, actions are valuable from both perspectives to achieve progress in insect conservation and to develop peoples' action competence that enables them to take further and even more effective actions. Evaluating actions and reflecting on benefits and limitations of prior actions can contribute to a refinement of future actions.

Applying the ACIC framework in this way takes the range of root causes and individual action possibilities into account. This reduces the risk of transferring naive ideas of how to solve the problem, and helps to address the complexity of the issue. We did not include actions to mitigate climate change or other general sustainable actions into the framework, since this would include many actions that are less directly connected with the issue. However, it is important to emphasize that the issues of sustaining insect biodiversity, mitigating climate change, and sustainability in general are closely related. The actions included in the

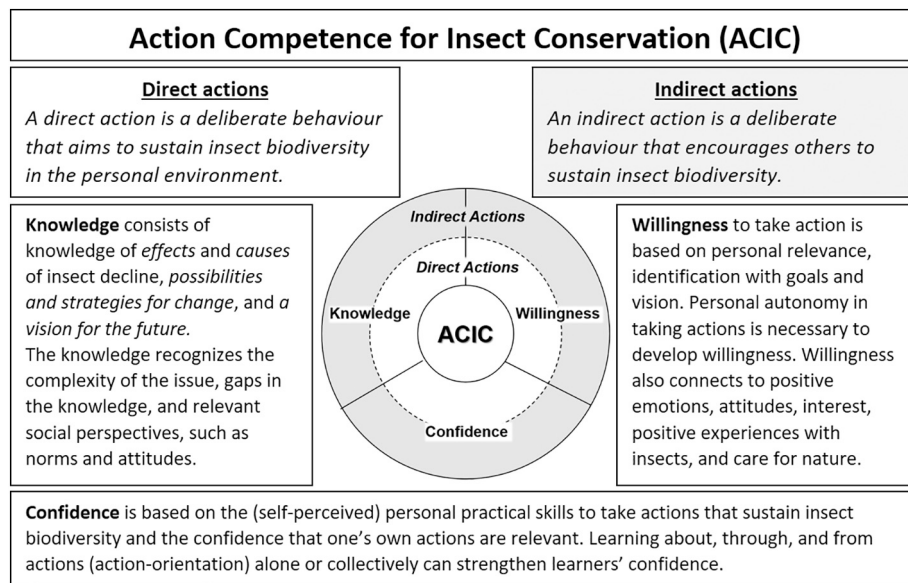


Fig. 2. Graphical summary of the ACIC framework.

ACIC-framework align with actions that contribute to create a sustainable future.

7.1. Concrete applications of the ACIC framework

A first central application of the ACIC framework is that it provides a theoretical basis for design and advancement of educational approaches in both formal educational settings (primary and secondary schools and universities) and informal educational settings (botanical gardens, zoos, scientific outreach, initiatives by NGOs or environmental associations, work with stakeholders). An educational design based on the ACIC framework considers all three dimensions of action-oriented knowledge, learners' confidence to take actions, and learners' willingness to act. Section 6 includes background information on all three dimensions to support such a design, which can be connected with general ideas on developing powerful learning environments (Sinakou et al., 2019). The ACIC framework can help to put the guidelines of conservation literacy (Trombulak et al., 2004) into educational practice. The presented framework therefore provides a theoretical grounding to answer calls for more education and more action in the field of insect conservation (Cardoso et al., 2020; Harvey et al., 2020).

A second application of the ACIC framework is that it provides a theoretical foundation to develop novel research instruments to investigate educational approaches in the field, an area that is currently underexplored. With the help of such instruments, it would be possible to investigate the knowledge, confidence, and willingness to conserve insect biodiversity of learners or other stakeholders. Applying these instruments in formal and informal educational settings could provide insights into how peoples' action competence changes during an initiative/intervention or to identify obstacles for taking actions. This knowledge can then help to improve or expand initiatives, so that people can foster their individual competences. Hence, the ACIC framework can boost research on social aspects of insect conservation, which is currently very limited, despite the manifold initiatives working with pollinator conservation. By this, the ACIC framework builds a theoretical foundation to answer the calls for more social and educational research in the context of insect conservation (Hall and Martins, 2020; Ruck and Mannion, 2021; Schönfelder and Bogner, 2018).

7.2. Final conclusion

We urgently need a society where individuals of all age groups and

social groups have well developed competences to take actions to sustain insect biodiversity, and are confident and willing to do so. Actions by individuals are needed to achieve insect conservation goals (Kawahara et al., 2021; Wagner et al., 2021). Even though the capacity of any one individual is small, taking several actions together has a broad capacity to support insects (Knapp et al., 2021). The ACIC framework supports the engagement in both direct actions in the personal environment and indirect actions that aim to engage other stakeholders to tackle the root causes of insect decline on a large scale. Engaging in concrete actions appears to be crucial to develop personal confidence, action-oriented knowledge, and willingness to take further actions. At the same time, engaging in actions can evoke excitement, fascination, and even empathy with insects (Ruck and Mannion, 2021). The presented ACIC framework provides a basis to develop democratic action-oriented educational approaches, and to conduct further research in this underexplored area. By this, the ACIC framework shall contribute to a transformational change towards a society appreciating and sustaining insect biodiversity.

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CRediT authorship contribution statement

Peter Lampert: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition. **Dave Goulson:** Validation, Writing – review & editing. **Daniel Olsson:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing. **John Piccolo:** Validation, Writing – original draft,

Writing – review & editing. **Niklas Gericke**: Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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