Raspberry Pi Foundation

Pedagogy Quick Read

Addressing learners’ alternate conceptions in computing

Alternate conceptions (often referred to as misconceptions) are learners’ beliefs about a concept that are overly simplified or inaccurate. When these beliefs contradict with reality or accepted scientific understanding, they can cause confusion for learners and affect their understanding and performance.[1]

Alternate conceptions in computing

We suspect there are a number of alternate conceptions around computing, though there is currently only limited research in this area. However, there is some research specifically related to programming, where a number of common alternate conceptions have been identified. We have looked at research into alternate conceptions in other subjects that form the traditions that underpin computing, in particular maths, science, and engineering.

Some psychologists claim that alternate conceptions can be very persistent.[2] In presenting learners with accurate conceptions that challenge their existing understanding, a state of “**cognitive disequilibrium**”[3] is reached where learners must reconcile the conflicting information. While this creates an opportunity to replace an alternate conception, learners may choose to discard information that doesn’t fit their existing mental models, regardless of its accuracy. It is important for educators to be aware of common alternate conceptions that their learners may pass through. Educators should develop a range of strategies to support learners through their alternate conceptions and to encourage them without labelling learners’ understanding as ‘wrong’.

Summary

Alternate conceptions can develop when new knowledge conflicts with a learner’s existing mental models.

Alternate conceptions can be categorised as:

- Preconceived notions.
- Non-scientific beliefs.
- Conceptual misunderstandings.
- Vernacular misconceptions.
- Factual misconceptions.

To become familiar with commonly occurring misconceptions, educators should:

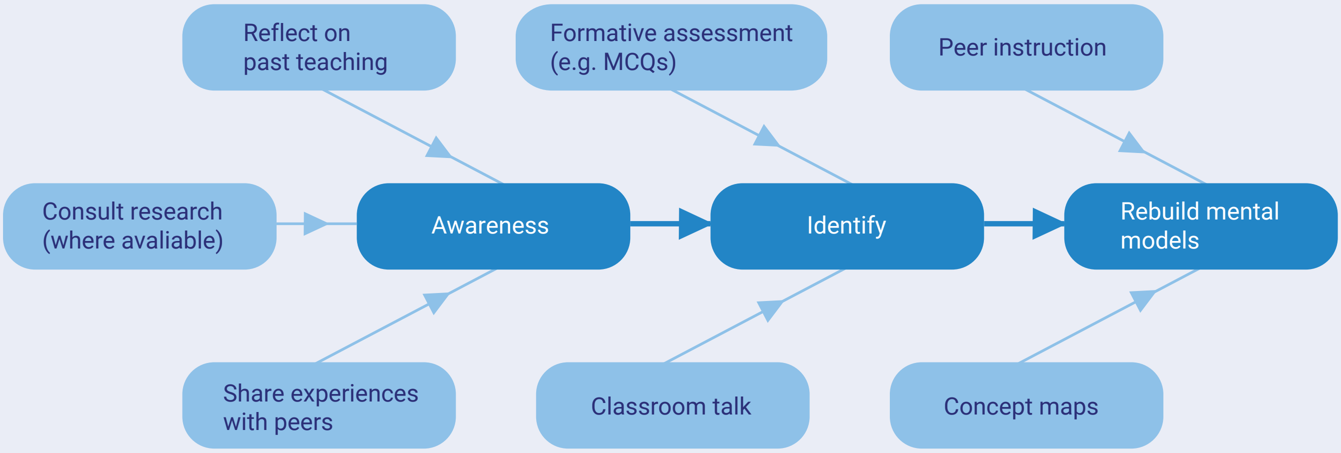
- Review existing research into alternate conceptions in computing.
- Reflect on their own experience.
- Share common alternate conceptions among peers and within the community.

Educators can identify alternate conceptions through:

- Varied opportunities for classroom talk.
- Multiple choice questions.

Effective ways to address alternate conceptions include:

- Constructing individual or group concept maps.
- Reaching consensus around a concept using peer instruction.



Steps and associated activities in managing alternate conceptions in computing

Origins of alternate conceptions

According to Piaget,[3] learners build new understanding by combining experience with existing mental models. An alternate conception can arise when learners' experiences and existing mental models interact.

Research [4] from science education proposes five categories of alternate conceptions:

- **Preconceived notions** involve learners making intuitive conceptual leaps based on their everyday experience. They use their pre-existing experience to fill in the gaps in their understanding. For example, learners who are used to programming in Scratch, may expect a text based language to handle concurrency for them.
- **Non-scientific beliefs** can arise when learners' mental models have been informed by non-authoritative sources. These beliefs are counter to accepted science. An example from programming is the superbug,[5] a belief that a computer possesses innate intelligence, which can cause the learner to have unrealistic expectations of the machine.
- **Conceptual misunderstandings** occur when the instruction learners experience is insufficient in its depth. The experience fails to challenge existing mental models and confront conflicts, leaving learners to resolve them independently. In computing, we regularly use analogies to unpack and explain abstract concepts. Learners may only develop a surface understanding unless educators spend time distinguishing between the concept and analogy (see our **Quick Read about semantic waves**).
- **Vernacular misconceptions** occur when terminology and symbols have multiple meanings. This causes new knowledge to conflict with existing mental models. Computing shares many terms and symbols with mathematics, for example, variables, graphs, etc.
- **Factual misconceptions** derive from false facts or information that have been assimilated into memory without being challenged. In science, an example is the idiom "lightning never strikes the same place twice" which may be believed despite being false. A similar example in computing is the common belief that "Apple Mac computers are immune to viruses".

How to identify alternate conceptions

The first step in minimising alternate conceptions is **identification**. Before teaching new material, educators should reflect on alternate conceptions in computing that their learners might develop. They could review existing research into common alternate conceptions. For computing, this is largely limited to programming [6, 7] here are some examples:

- A variable can store multiple values; it may store the history of values assigned.
- Both then and else branches (in a selection statement) are always executed.

For alternate conceptions in other areas of computing, educators should reflect on the alternate conceptions they have seen occur in computing lessons, sharing these and learning with their peers. Computing educator communities are great places to discuss alternate conceptions, along with blogs, books,[8] and other publications. Examples taken from other areas of computing include:

- The internet and the World Wide Web are the same thing, rather than being a network and an example of a service that runs on that network.
- Binary numbers can only represent numbers up to 255 in denary.

Beyond awareness of potential alternate conceptions, educators also need strategies to spot them as they occur. There are a number of techniques that can be used to help identify alternate conceptions (but aren't limited to):

- Classroom talk and discussion. Both are useful methods to reveal alternate conceptions.
- Carefully designed multiple choice questions (MCQs). MCQs can probe learners' understanding and emphasise alternate conceptions.

How to challenge alternate conceptions

Many alternate conceptions, particularly vernacular and factual misconceptions, can be addressed during instruction. However, others require more work as the learner already holds a model, albeit flawed, which they may be reluctant to replace. To address these persistent alternate conceptions, learners need the opportunity to construct (or reconstruct) an accurate model. Educators can provide this opportunity by:

- Constructing **concept maps** to help externalise learners' understanding and emphasise their alternate conceptions so that an accurate model is adopted.
- Using **peer instruction** to let learners explore and challenge their own mental models.

In approaching alternate conceptions, there is no singular approach that will work for all learners, all of the time. However, educators who are able to identify their learners' common alternate conceptions are better equipped to support their learners' understanding,[9] development, and confidence.

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