Philosophical Aspects of Fundamental Ideas: Ideas and Concepts

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Abstract: We consider the term ªidea from a philosophical point of view. In particular we are interested in the concept s origins, its relevance to human thinking and in particular in its pedagogical value for computer science lessons in schools as well as universities. Since the concept of fundamental ideas in computer science has been seized, extended, and reviewed by other authors and applied to lessons, often with a different understanding of the defined terms, we wish to explain some of the objectives of the approach in more detail and in particular clarify the relation between concept and idea in order to provide a common understanding of the relevant notions.

1 Introduction

In this paper we extend long-term considerations on fundamental ideas of computer science first published in [Sc93] (see [Sc94] for a revised version in English and [Sc97] for an extended abstract). While the earlier papers focus mainly on the definition and background of fundamental ideas, here we try to consider the notion ªidea from a philosophical point of view. In particular we are interested in the concept s origins, its relevance to human thinking and in particular in its pedagogical value for computer science lessons in schools as well as universities. Since our concept of fundamental ideas of computer science has been seized, extended and reviewed by other authors [B98, Mo03a, Mo03b], applied to lessons, and included into curricula [BEL02] often with a different understanding of the defined terms, we furthermore wish to explain some of the objectives of the approach in more detail. In particular the notions of concept and idea are often mixed-up. As a consequence sometimes concepts, like the Turing machine, or subjects of computer science, like date bases, are erroneously denoted as ideas. So this paper attempts to clarify the relation between a concept and an idea in order to provide a common terminology of the relevant notions.

For the rest of the paper we assume that the reader is familiar with [Sc93] resp. [Sc94] or the relevant sections in [SS04].

2 Philosophers on ideas

By an idea one often denotes a plan, a thought, an imagination or an

> [a]object of a non-sensory intellectual perception, in which its nature may be recognized [1] [Enzyklop die der Philosophie].

In particular in philosophy the concept of ideas has a long tradition. Later it has been reconsidered in the field of education [B60]. But while philosophical papers often try to make the notion as precisely as possible, many pedagogical papers on fundamental ideas show a considerable deficit, at least for a formal scientist, if it concerns an exact clarification of properties and attributes of ideas. A typical approach is to give few examples for ideas and one or two criteria. As to the author s knowledge the philosophical contribution to clarify the notion and pedagogical relevance of ideas has not been analyzed so far. Even in an earlier paper of Schweiger [Sc92] these aspects are omitted although the title might suggest the contrary.

In the following we want to summarize the most important philosophical considerations of the notion of an idea, since they give interesting indications for the pedagogical value of an idea in computer science education.

The notion of an idea dates back to Plato and has been reconsidered later by Descartes, Locke, Hume and Berkeley, however with a different meaning. It was not until Kant who returned to the Platonian notion of idea. In the following we wish to analyze the main properties of ideas as far as they help clarify the notion.

2.1 Plato (427-347 BC)

Plato has the most abstract vision of ideas. Besides reality they form a class of its own, a cosmos of pure objects (a higher reality) located at a celestial place, i.e. independent of human thinking. Every real object is just an imperfect copy of the ideas behind it. Typical Platonic ideas are the idea of a circle, of a chair, of justice, of the good, of beauty which only have imperfect copies in reality. The function of ideas is normative: they provide guidelines that humans might approach.

All Platonian ideas are innate and thus the basis of human perception. Every human being, at the time of birth, has the chance to have a short look into the heaven of ideas. Then perception occurs not by acquisition of a new idea but by recalling ideas acquired earlier.

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[1] [a]Gegenstand einer nicht-sinnlichen intellektuellen Anschauung, in der sich dessen Wesen zu erkennen gibt.

In summary: Ideas are certain abstract ideal imaginations of objects that are not available in reality but that act as models for human behavior or real objects and thus define objectives which humans try to achieve approximately. This normative aspect which we consider very important for didactic issues will be discussed again later.

With Descartes and later Locke, Leibniz, Hume and Berkeley ideas lose their cosmological attitudes; yet, the term "idea" eventually develops to denote every act of thinking and becomes a synonym for "concept". It was Kant who once again distinguishes between these two terms.

2.2 Descartes (1596-1650)

Also Descartes considers ideas as images but in contrast to Plato he exchanges archetype and image:

Plato: ideas → real objects.
Descartes: perceived objects → ideas.

Now real objects are no longer imperfect copies of a Platonic idea which are already (prenatally) in the (sub-)conscious mind but conversely ideas are images of objects perceived by the conscious mind. Furthermore Descartes significantly extends the meaning of idea and uses "idea" as a superordinate concept for all objects in the mind, i.e. "everything ... that is directly perceived by the mind". By admitting that the mind is able to perceive and to develop new ideas by its own Descartes negates that all ideas are innate. He distinguishes between innate ideas, perceived ideas and ideas that are developed by the human him- or herself. Here the innate ideas may not be considered a fixed collection of objects of the mind but as abilities for acquiring and developing ideas (Fig. 1).

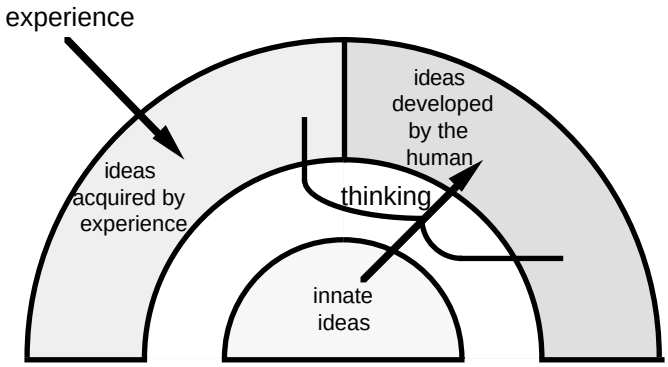

Fig. 1: Ideas and their role according to Descartes

2.3 Locke (1632-1704)

A definite breach of Plato's doctrine of ideas is done by Locke, a co-founder of empirism. In [L] he analyses

> [a]the original of those ideas, notions, or whatever else you please to call them, which a man observes, and is conscious to himself he has in his mind; and the ways whereby the understanding comes to be furnished with them [L: I,1,3].

and distances himself from Plato by defining [a]idea as a notion that

> [a]serves best to stand for whatsoever is the object of the understanding when a man thinks [L: I,1,8].

Here [a]thinking is very widely used and not only covers the intrinsic operations of the mind but also sensory perceptions, senses of pain, remembrances and concepts, for instance warmness, movement, or color.

Another novelty of Locke s is the absolute rejection of innate ideas. In fact for him the mind is a [a]white paper, void of all characters, without any ideas [L: II,1,2], a tabula rasa in which all experiences are imprinted as in a wax tablet. These experiences are subdivided into two classes, *sensations* and *reflexions*. In this framework knowledge is acquired based on [a]the perception of the agreement or disagreement of any of our ideas [L: IV,3,1].

Furthermore Locke develops a detailed classification of ideas. He distinguishes between simple elementary and complex ideas. Softness, warmness, color are *simple ideas*. *Complex ideas* are subdivided into ideas of *substance*, *relations*, and *modes*. Another classification concerns the operations by which the mind is able to combine simple ideas to complex ideas: *composition*, *comparison*, and *abstraction* (Fig. 2).

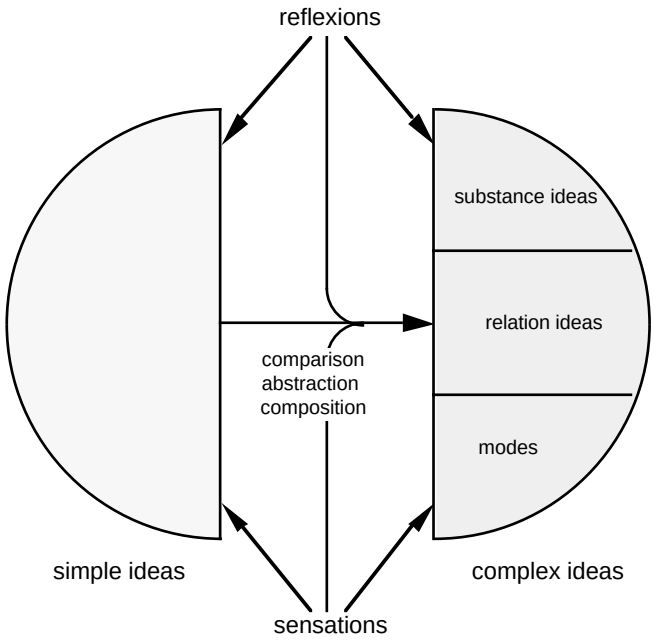

Fig. 2: Ideas and their operations according to Locke

Summarizing Locke s wide use of the notion of ideas containing any operations of the mind is not suitable for our educational purposes. On the contrary with respect to our didactic objectives we wish to distinguish sharply between scientifically correct and formalized concepts on a high intellectual level and ideas which underlie, explain, and motivate the concepts and are supposed to be more simple and easier to learn. For our considerations we can profit from Locke s observation that all ideas are based on a certain set of simple ideas and hence may be structured according to their complexity. Of particular interest are the operations of composition and abstraction which may lead to a hierarchical structure of more and more complex and abstract ideas.

2.4 Leibniz (1646-1716)

The proof that there are no innate ideas is not always coherent in Locke s work and refuted by Leibniz who defends Descartes conception against Locke. Furthermore he restricts Locke s widely used term of idea. Leibniz considers an idea not to be a certain act of thinking but an ability[2]; traces of impressions in the mind are not ideas[3]. Leibniz distinguishes between ideas and concepts but classifies concepts as part of the ideas. He also accepts the existence of innate ideas.[4]

2.5 Hume (1711-1776)

Hume s merits consist among others of a more detailed analysis and classification of processes in the mind as well as a detailed structuring of the processes that guide the development of ideas.

While Locke refers to all contents of the mind as ideas, Hume distinguishes between impressions and ideas, where impressions are vivid and strong and ideas are weaker and less vivid. They arise

- from a sensory perception (*sensation*), e.g. by hearing, smelling, tasting, seeing, for instance the impressions of loud, hot, bright,
- from *reflexion*, e.g. emotions, for instance the reflexions of joy, pain, hate,
- by recalling ideas (*memory*) acquired earlier, for instance remembering an earlier incident.

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[2] Die Idee besteht f r mich nicht in einem bestimmten Akt des Denkens, sondern in einem Verm gen, so da§ wir die Idee eines Dinges haben k nnen, selbst wenn wir nicht wirklich dar ber nachdenken, doch bei gegebner [sic] Gelegenheit dar ber nachdenken k nnen. [Le]

[3] Spuren von Eindr cken in unserem Gehirn sind keine Ideen. [Le]

[4] In dieser Weise sind uns die Ideen und Wahrheiten eingeboren als Neigungen, Anlagen, Fertigkeiten oder natuerliche Kraefte, nicht aber als Taetigkeiten, obgleich diese Kraefte immer von gewissen, oft unmerklichen Taetigkeiten, welche ihnen entsprechen, begleitet sind. [Le1]

Impressions are either *simple* or *complex*, i.e. composed from simple impressions. An example of a simple impression is the color yellow, while the impression of an apple is complex and may be subdivided into simple elementary impressions like red, round, sweetish smell.

Ideas are derived from impressions, but they lose their strength and vividness during that process. In analogy to impressions they may be subdivided into simple ideas and complex ideas where there is a bijective relation between simple impressions and those simple ideas which they are originally derived from. Complex ideas are not preceded by corresponding complex impressions. Rather they are established using *imagination* that has the ability to combine simple and complex ideas in order to obtain new ideas or to reorganize ideas. So there is a causal relation between ideas and impressions in the Aristotelian sense that there is nothing is in the mind what has not been in the senses before (Fig. 3).

Hume admits the existence of innate ideas. For instance, reasoning from experiences in the past to incidents in the future is based on an innate idea: otherwise creatures would have very small chances to survive if this idea were only established during a longer process of experience and reflexion.

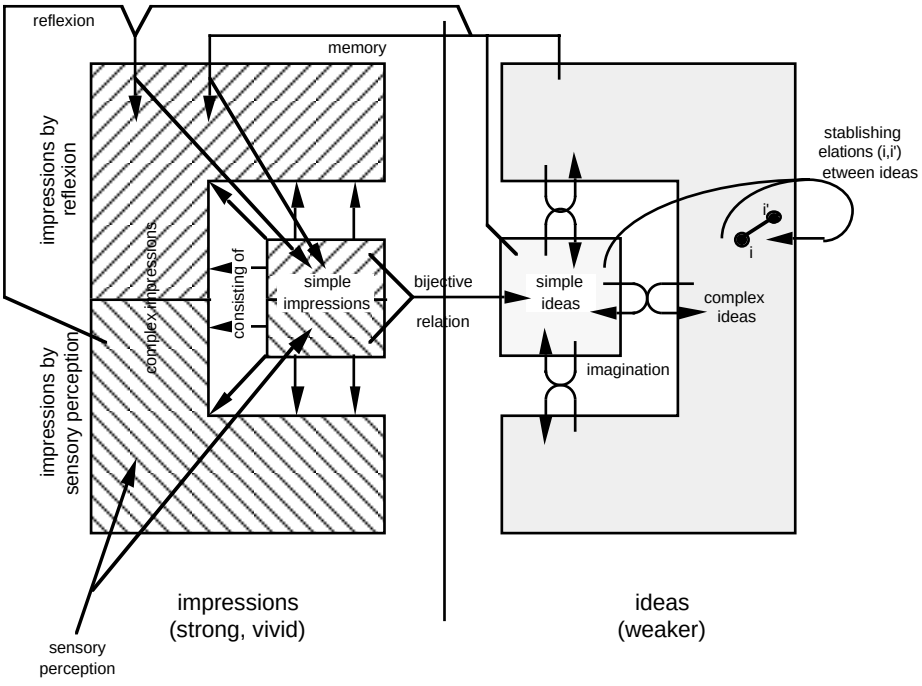

Fig. 3: Operations on impressions and ideas according to Hume

Conclusion: For our purposes Hume s considerations are useful only in two respects: On the one hand ideas may be — as also shown byLocke —distinguished according to their complexity and structured hierarchically where the number of compound operations

imagination has to perform may serve as a measure of complexity or hierarchical level. Moreover all ideas rely on certain basic ideas. On the other hand ideas developed earlier are included into processes of the mind by reflexive self-perception. We may assume that they control and influence this process to some degree. We remark that Hume as well as Locke unfortunately do not distinguish between an idea and a concept.

2.6 Kant (1724-1804)

Kant s analysis of human cognitive processes gives us major innovations and precisions of the notion of ideas and their function. In the following we focus on his main work [a]The Critique of Pure Reason [K].

2.6.1 Overview on [a]The Critique of Pure Reason

Kant continues the rationalistic considerations of Leibniz. Let us return to Locke s metaphor that all experiences are engraved into a wax tablet that is completely empty when the human is born. Leibniz had already refuted Locke by argumenting that the wax tablet has to have a particular structure in order to be able to store experiences at all, since experiences can only be made if they are carved into the tablet. Signals that reach the tablet on another way, be it optically or acoustically, are not recorded and not turned into experiences. So there has to be a certain match between signals that carry experiences on the one hand and the sensors as well as the perceptional processes of the mind on the other hand in order to make experiences at all. These properties that sender and receiver have to have in common are analyzed by Kant in the [a]Critique of Pure Reason concluding that it is not experience that determines perception but conversely that experience to a large extent is a product of our mind. All structures that we may find in our experiences were prescribed by the mind:

> [a]The understanding does not derive its laws (a priori) from, but prescribes them to, nature. .[5]

Hence, objective perception is not possible since all experiences are formed and modified by the mind before they become perceptional material. According to Kant the structures that enable and guide perception are divided into three levels with increasing distance from the objective reality:

- the *pure forms of perception*[6] space and time which influence the perception of every object. So the mind does not perceive the real objects (the [a]Ding an sich) but only their appearances which have been modified by pure forms of perception.

- the *pure* concepts of understanding[7], so-called *categories*, like quantity, causality, possibility, necessity, which form the notional framework for every form of human thinking; they are pure forms for constituting experiences.

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[5] Der Verstand sch pft seine Gesetze nicht aus der Natur, sondern schreibt sie dieser vor [K1, /36]

[6] [a]reine Anschauungsformen

- the *pure concepts of reason*, so-called *transcendental ideas*, like soul, world, God, which as idealized objectives establish the methodology for extending knowledge. This aspect will be analyzed in more detail as it is interesting for our educational purposes.

2.6.2 Kant on ideas

Kant turns away from his predecessors and contemporaries notions of ideas and returns to the Platonic concept but with some major modifications. First he carefully distinguishes between ideas, perceptions, imaginations, notions, concepts etc. He assigns ideas to the category of representations and classifies as follows [K, B376/377]:

- A representation with consciousness is a *perception* (perceptio).
- A perception which relates solely to the subject as the modification of its state is *sensation*.
- An objective perception is *knowledge* which may either be an intuition or a concept.
- An *intuition* is singular and relates directly to an object.
- A *concept* is indirectly related to an object in terms of an attribute that several objects may have in common. We may distinguish empirical and pure concepts.
- A pure concept has its origin in the understanding alone and is called *notion*.
- A concept that exceeds the possibility of experience is called an *idea* or concept of reason.

Kant defines [a]idea explicitly at many different places in his works, namely as

- a concept in such a perfection that cannot be found in experiences,[8]
- a necessary concept of reason which has no corresponding object in sensory experience.[9]

So ideas are results of pure thinking and cannot be found in experience at least not in the imagined form but solely as imperfect copies, so were the Platonic ideas.

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[7] [a]reine Verstandesbegriffe

[8] [a]Eine Idee ist nichts anderes als der Begriff von einer Vollkommenheit, die sich in der Erfahrung noch nicht vorfindet. Z. E. die Idee einer vollkommnen [sic], nach Regeln der Gerechtigkeit regierten Republik! [K2, VIII, 196]

[9] [a]notwendiger Vernunftbegriff, dem kein kongruierender Gegenstand in den Erfahrungen gegeben werden kann [K, B384]

2.6.3 What is the methodological relevance of the Kantian ideas?

Every human cognition begins with a sensory experience which is modified by the pure forms of perception (time and space). Afterwards these experiences are structured conceptionally along the question ªwhat is using the pure concepts of understanding (categories). Finally, the pure concepts of reason (ideas) organize the acquisition of concepts of understanding along the question ªwhy holds ...? or ªhow are things related? , and they define the objective for the mind to search for a maximal unity (systematic) of the perceived material, thus setting a direction for this search. So roughly (Fig. 4):

- pure forms of perception modify perceptions to intuitions
- categories organize intuitions towards concepts
- ideas guide the mind to extend concepts towards a total uniformity.

Which ideas are, as driving forces, responsible that we aim at a maximal uniformity and systematic of all insights? This question has to be answered for any science and the results have to be carried over to school and university curricula in order to teach students a correct view of the respective science. For computer science a first attempt is contained in [Sc93,SS04].

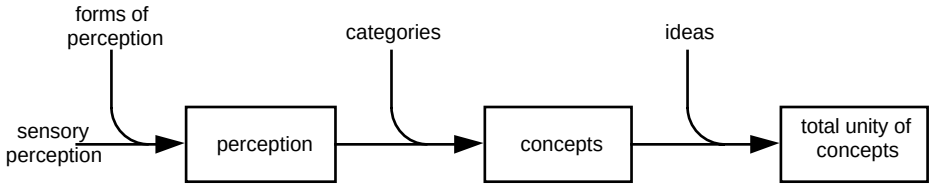

Fig. 4: Cognitive processes as seen by Kant

2.6.4 The regulative function of ideas

Kant has analyzed very carefully the use of ideas of reason versus categories of understanding. While concepts help understand facts by constituting knowledge (by definitions, theorems, proofs), the function of ideas is *regulative*. They guide the mind to extend its knowledge, by searching for suitable experiences, towards objectives that are described by ideas. However, a problem arises if one tries to obtain results about the ideas themselves, i.e. not using them regulatively but constitutively like concepts. Considering ideas as objects instead of objectives and trying to draw conclusions or making proofs about them, inevitably leads to contradictions. Kant proves that by showing that both the assumption of the truth of an idea as well as its negation lead to a contradiction. The reason for this lies in the attempt to obtain results on ideas that lie beyond experience, an inherent property of ideas as shown earlier in this paper.

Example: Let us consider the idea of finding a primal incident initiating the beginning of time (big bang theory). Assuming time has a beginning as well as it has not leads to a contradiction, because we try to use the idea of finding the first causal incidence in a

constitutive way as an assertion instead of using it in a regulative way as a concept of desire.

In summary: Ideas are idealized imaginations which objectives are attached to that may not be experienced. However, they guide the human impulse to research and instruct the mind to extend its knowledge towards these objectives possibly without ever reaching them. In [SS04] we have denoted this property of ideas the *goal criterion*.

Now we wish to consider three aspects of this criterion in more detail, since they give hints why ideas have a particular relevance for science and education:

- the *methodological aspect* of ideas is oriented to science. It covers the property of ideas to set up rules, principles, methods and schemes for acquiring knowledge. This aspect seems particularly relevant for computer science that appears to be an ªengineering science of the mind or a ªscience of humanities and engineering [10] [B74] or an ªapplication-oriented science of methodology [11] [CS01] and always combines research on its objects with research and further development of its methods. So what are the methods of computer science in terms of fundamental ideas?

- the *psychological aspect* covers the motivating attributes of ideas: Their dynamic and process-oriented character is the driving force that activates humans to do research. So, if based on ideas, lessons become more transparent and meaningful for students because they gain along with scientific knowledge answers to questions like ªwhat do I wish to achieve? or ªwhere do I want to go? . So their activities obtain a direction and may be understood as steps on a scientific way towards an objective.

- the *normative aspect* covers current objectives of scientific research and makes a contribution to clarify the paradigm of computer science in the sense of T.S. Kuhn [K62] who defines a paradigm to be a consensus of the scientific community, i.e. a collection of solutions to concrete scientific problems that the community has come to accept. Computer science, even with a historical background of some 50 years, still develops dynamically and has not elaborated a generally-accepted paradigm[12]. On the contrary continuous paradigm changes are announced. The normative aspect of fundamental ideas will be discussed elsewhere in more detail.

3 Ideas and concepts

Several times in our previous considerations we have implicitly distinguished between idea and concept. Now we wish to separate these terms more carefully. In particular for the didactic purposes in [Sc93,SS04] this separation is essential. Consequences of a mix-up of these two terms may be seen from aberrations in mathematics education in the

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[10] ªGeistes-Ingenieurwissenschaft or ªIngenieur-Geisteswissenschaft

[11] ªanwendungsorientierte Methodenwissenschaft

[12] On the other hand P. Wegner [W83] concludes that for an interdisciplinary science as is computer science peaceful coexistence of several paradigms is in fact a hint for scientific maturity.

past. In the sixties approaches to redesign mathematics education based on J.S. Bruner s concept of fundamental ideas [B60] lead to a fundamentalist reorientation towards Bourbaki s mother structures and eventually to the integration of set theory in primary school. This development which may retrospectively be regarded as failed based on a misinterpretation of Bruner s principle to focus on structures of science and on an incorrect identification of concept and idea.

The following table summarizes main aspects of ideas and notions.

concept (in German: Begriff)	**idea (in German: Idee)**
Concepts cover the permanent aspects of an object and its essence; they describe what an object is.	Ideas postulate a certain essence of objects; they describe what an object should be.
Concepts emerge from objects by grasping their essence, i.e. by abstraction of essential properties of different single objects and unification.	Ideas precede objects as an eternal perfect model. Objects (even if imperfect) emerge by concretisation of ideas.
Objects a concept is derived from originate from experience.	Objects, which an idea is underlying, occur only as imperfect copies in experience.
Concepts are more general and therefore poorer, less concrete and less varied with respect to their meaning, since they are abstractions of all single objects that belong to the concept.	Ideas are richer and more perfect than the single objects imperfectly cloned from ideas.
Concepts are static and product-oriented. They are snapshots of a learning or research process but do not clarify this process, its starting point or its aim.	Ideas are dynamic, vivid and describe a methodical process, i.e. a path that is paved with ideas, as well as origin and objective of this process.
Concepts are operands of thinking.	Ideas determine which operations of thinking on which operands are performed.
Concepts assert facts (constitutive aspect).	Ideas express (possibly unsolvable) tasks to establish facts (normative/regulative aspect).
Concepts structure cognitive material on the level of understanding by unifying and organizing a multitude of experiences.	Ideas control the process of understanding on the level of reason and determine how and in which direction to extend knowledge.
Without concepts science is not possible, since one cannot establish a systematic relation between the surge of single possible and real experiences.	Without ideas science is possible but the will to do it is missing. Only ideas give the motivation to create concepts, to aim at insights and to extend them in a certain direction.

4 Conclusions

In this paper we have contributed to a unique and common terminology in the field of fundamental ideas of computer science, a task that is inherent for doing science but far from being done in the field of didactics of computer science or even in computer science itself. We have compared the two notions [a]idea and [a]concept and collected characterizing properties from philosophical works over the centuries which hopefully may clarify some of the recent discussions and interpretations of this didactic approach and lead to a correct use of the terms in the didactic discussion. But while the technical effort is tremendous the results appear tiny and unimportant, yet the approach shows that gaining standards in terminology, not mentioned standards in educational objectives or curricula, is a long-term process in particular for a non-formal science like didactics.

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