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Evaluating research: A multidisciplinary approach to assessing research practice and quality

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ABSTRACT

There are few widely acknowledged quality standards for research practice, and few definitions of what constitutes good research. The overall aim was therefore to describe what constitutes research, and then to use this description to develop a model of research practice and to define concepts related to its quality. The primary objective was to explore such a model and to create a multidisciplinary understanding of the generic dimensions of the quality of research practice. Eight concept modelling working seminars were conducted. A graphic representation of concepts and their relationships was developed to bridge the gap between different disciplines. A concept model of research as a phenomenon was created, which included a total of 18 defined concepts and their relationships. In a second phase four main areas were distilled, describing research practice in a multidisciplinary context: *Credible*, *Contributory*, *Communicable*, and *Conforming*. Each of these was further specified in a concept hierarchy together with a defined terminology. A comprehensive quality model including 32 concepts, based on the four main areas, was developed for describing quality issues of research practice, where the model of research as a phenomenon was used to define the quality concepts. The quality model may be used for further development of elements, weights and operationalizations related to the quality of research practice in different academic fields.

1. Introduction

1.1. Background

A fundamental question that can be posed within any field of research is 'What constitutes good or high quality *research* (*or scientific*) *practice*?'. This question is relevant for research both in a university context and in an organizational or innovation context for research and development activities. However, before such criteria can be formulated, we need a reasonably common understanding of what research itself really is.

Science and research are ontologically challenging, and previous research reveals different views and remains ambiguous. A recent definition of science was proposed by the British Science Council: "Science is the pursuit of knowledge and understanding of the natural and social world following a systematic methodology based on evidence" (Science Council, 2009: www.sciencecouncil.org/definition). Based on somewhat similar definitions, several studies have explored the concept of *research*. In this respect Israel (2005) acknowledged and explored the complexity of science, Patton (1990) mentioned that it is important to identify the purpose of research, and Gall et al. (1996) discussed how research might contribute in the field of education. In the medical domain, Grinnell (1990) argued that the endings of clinical research protocols are of importance in distinguishing therapy from research. In 2000 the same author stated that the everyday practice of science is neither realism nor social constructivism, but rather is balanced on a contextual ledge between the two, and said that he considered discovery and credibility to be the two central features of research (Grinnell, 2000). Ulrich (2006) has analysed different traps that are currently common and that lead to a somewhat limited reflective

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research practice, and he describes a rethinking approach. Further, Quaye (2007) argues for extending what counts as research within the social sciences so that it is more likely to include different methodologies and writing genres. Nickelsen (2009), in a similar approach, supports the notion of interventionist research that is not just focused on simple one-way causation in the field that is being studied. In parallel with this, there has been ongoing discussion about rethinking knowledge production in general (e.g. Hessels and van Lente, 2008; Tsao et al., 2008). In this new mode of knowledge production, often referred to as Mode 2, knowledge is produced in the context of an application (Gibbons et al., 1994). Knowledge can be produced in different contexts, and the concepts of 'knowing in action' (Amin and Roberts, 2008) and 'situated learning' (Lave and Wenger, 1991) highlight the importance of a variety of contextual factors. It is important to keep this in mind, not least in the light of the considerable amount of knowledge production taking place in Research and Development (R&D) departments in companies.

In summary, there is broad criticism of the so-called linear model of science, and it is argued that concepts such as intuition and passion have become just as important as objectivity and logic (Dash, 2009; Grinnell, 2009), and there are several very different views on, and definitions of, research practice. In our paper we therefore concentrate our efforts on working towards a generic definition (or model) of what research is. Then, based on this model, it may be possible to define the generic components of quality of research practice.

However, before describing and discussing our study and the resulting model, we need to clarify the terminology used. In some publications and websites on this topic, there seems to be some confusion between the term *research* and the term *science*, and these terms seem to be used interchangeably. In our view the term science is broader, and research is more like the *practice* of working in a scientific manner. Research is what you practise, and the result of this work is science. We have used the terms *research* and *research practice* throughout this paper, as the scope of our study comprises trying to define what high quality science production might be.

Moreover, as the evaluation of research practice is one of our end-goals, we may also need to define what we mean by *evaluation*. In our view, the practice of evaluation can be defined as an activity in which certain aspects of the quality of research practice are investigated. But what does this really mean? The ambition to evaluate research has a long history that is full of tensions, ambiguities and misunderstandings. Some countries have formed national commissions for evaluating research, which seem to focus on bibliometric analyses to measure research quality (Jiménez-Contreras et al., 2003), but the evaluation of research may include many other aspects. The current debate is for example highlighting the problem of having evaluations "led by the data rather than by judgement" (Hicks et al., 2015: 429). An often cited definition of evaluation is "...a process for collecting and synthesizing evidence that can make conclusions about the state of affairs, value, merit, worth, significance or quality of a program, product ..." (Mathison, 2005), which implies that evaluation can use numerous methods and measure a wide variety of aspects (see also Mertens, 2015).

1.2. Dimensions of the quality of research practice

Evaluation of the quality of research practice is a truly important issue in most scientific domains and at many levels (European Science Foundation, 2012). Increasingly, we are also seeing these assessment efforts across disciplinary and national boundaries. More or less elaborate efforts have been made in recent years to evaluate the quality of research practice in a host of different settings. These efforts affect resource allocation, scientific activity, and the very lives of researchers across the globe. Quality is the focus for several different reasons, and is examined in a variety of contexts such as in the evaluation of:

- research grant applications
- research manuscripts and publications
- specific research topics
- research groups and constellations
- institutions
- national systems for producing science and innovation

Regarding the issue of measuring the quality of research in the wider scientific community, it is difficult to find a universal definition of what constitutes good scientific practice. The focus at some universities is only on the number and quality of publications in scientific journals, whereas other institutions focus on all kinds of publications. However, in an increasing number of academic fields it is becoming more and more common for scientific output to be measured in ways other than simply counting the number and quality of publications.

Several costly quality-assessment projects have been undertaken lately to improve the quality of research practice at the authors' own institutions, to determine which research areas should receive funding, to find out whether and where quality improvements are necessary, and to benchmark the quality of a certain institution against that of leading international institutions. However, the available scientific literature on research quality, and on what can really be defined as research, is scarce. Some examples do exist. In Italy, for example, national reference guidelines for the evaluation of research practice have, in general, advocated an approach that includes socio-economic impact, resource attraction and resource management as criteria (CIVR, 2006). In the US, the criteria for evaluating research grant applications at the National Institutes of Health include short definitions of five concepts: significance, approach, innovation, investigators, and environment (NIH, 2008). In a recent evaluation of research constellations within a large university in Sweden, the quality of research practice was measured by considering the attention received concerning the scientific, technological, clinical and socio-economic significance of their publications, including the implementation of research results in society (External Research Assessment (ERA), 2010). In Sweden today, however, there seem to be at least as many ways to measure what constitutes a good scientific study or publication, as there are research institutions. In Canada, standard quality assessment criteria for research papers have been developed, and these deal separately with quantitative and qualitative research studies (Kmet et al., 2004).

However, it is not our goal to distinguish some types of scientific methods that are inherently 'good' from others that may be 'bad'. Our contention is that almost any scientific method can be appropriate, given a sound research design. It is the research question(s) at hand that should lead to the decision on which research design and method(s) should be used, and quality may be high as long as the methods are used with rigour and quality. In our view, theories can be seen as 'maps' and research methods as 'nets'; both are highly context dependent in how they find and capture the elements for producing new knowledge.

Quality assurance and evaluation measures are meant to be as objective and reliable as possible. They generally have the aim of increasing awareness about the current status and standing of the research that is underway. However, the general problem is that nearly all the recent evaluation projects have used different measures and weights for the applied variables, making it difficult to compare an institution's evaluation results with those of other institutions or disciplines. Specific examples of proxy variables that

have been used in the evaluations of the quality of research practice mentioned above include:

- Publication measures (e.g. number, quality and impact)
- Number and quality (academic degrees) of the researchers themselves
- Size of national and international scientific networks
- Amount and number of external research grants received
- Amount and number of intra-organizational grants
- Number of PhD theses produced
- Number of postdoctoral or guest researchers

The lack of widely acknowledged quality standards for research practice is somewhat surprising. A consequence of it is that judges of the quality of research – university boards, scholars, funding agencies, journal editors and journal reviewers – apply the values and standards of their own minds, fields or disciplines. To apply one's own values is part of the evaluation process, but having generally acknowledged quality standards, instead of developing idiosyncratic ones, is likely to make it easier to make fair evaluations. Although most quality evaluations have been performed within universities, private and public research-oriented companies and other scientific institutions have also carried out similar evaluations. Some of the quality evaluations hitherto have encompassed entire universities, while others have focused on certain disciplines like life sciences, information technology, and even more specific research topics like cancer, diabetes and life-long learning.

A following fundamental question is therefore how research carried out within a particular field should be evaluated. In addition to the difficulties of judging content, it is a complex process to attempt to apply a certain evaluation model that has been used in a specific setting to another subject domain, area, region or country. Furthermore, it is not necessarily the case that a specific set of evaluation criteria and weights that work well in, for example, medicine will work as well in the social sciences or engineering. Although there have been attempts to develop general quality criteria (e.g. Lahtinen et al., 2005) and methods for reviewing evidence in specific topics (e.g. Alborz and McNally, 2004), there are still general challenges facing many universities. There may be many different academic areas, faculties and departments, all of which want (or need) to be compared with one another.

In previous research on quality dimensions it has been shown that many models describing the quality of research practice can be used (e.g. Gummesson, 1991; Keen, 1991; Mason, 1996; Maxwell, 1996; Mårtensson, 2003; Mårtensson and Mårtensson, 2007; Rubin and Rubin, 1995; Sutherland et al., 1993), and that different suggested sets of dimensions often overlap in different ways. Some criteria, such as those of Klein and Myers (1999), focus on evaluating a specific kind of research. The authors present a set of principles "addressing the quality standards of only one type of interpretive research, namely the interpretive field study" (p. 69). In a similar fashion, Dubé and Paré (2003) discuss positivist case research. Others argue that certain dimensions are generally better suited to some kinds of research than to others; for instance, Rubin and Rubin (1995) argue that validity and reliability are better suited to quantitative research as they are not appropriate for qualitative research. A distinction is often made between rigour and relevance (e.g. Keen, 1991), and it is sometimes assumed, implicitly or explicitly, that there is a trade-off between these concepts. Robey and Markus (1998) argue that researchers should strive to produce research that is both rigorous and relevant, and they call this consumable research. In conclusion, specific criteria for evaluating the quality of research practice seem to be lacking, or at least they are not well defined. At the core of the problem is a contemporary debate over whether social science research meets the quality criteria of the natural sciences in terms of clear definitions of terminology, quantifiability, highly controlled conditions, reproducibility, and predictability and testability (Berezow and Hartsfield, 2012).

There is thus a need for determining a universal concept model for the quality of research practice. Further work to adapt and test the use and reliability of such a model in different domains and disciplines would then be desirable.

1.3. Aims

The general aim of this study is to present an actionable and multidisciplinary framework for the evaluation of the quality of research practice, that can be used as a guide in different scientific fields. Given the diversity and lack of uniformity in current assessment methods, this study seeks to bring some relief by making an inventory of the elements that constitute the very idea of research itself.

The primary objective of the first phase of this study was to create a multidisciplinary, fundamental concept model of research as a phenomenon, or, in other words, to describe 'what *research* really is', and also to differentiate research practice from other academic or professional activities. This concept model will be referred to as the *reference model*.

In the second phase the objective was to create a multidisciplinary and fundamental concept hierarchy for terms associated with the quality of research practice, or in other words 'what the *quality of research practice* is and how it can be defined'. These concepts were thought to be useful as a structure for identifying important dimensions of research quality across various fields. This concept hierarchy will be referred to as the *quality model*.

1.4. Limitation of scope

The focus in this project is on the quality of research practice, and thus on relevant aspects of the quality of research processes (that is, aspects of research processes that one would expect to be described and that are relevant under the applicable rules for descriptions). This means that the aim is not to try to capture *all* aspects of the actual research process, which could include, for example, frustration, perceived time pressure, numerous rewriting iterations, etc. Although these aspects are likely to occur often in a research process, the main focus here is, rather, on aspects of the quality of research practice, which in turn have implications on the outcome of this process. Moreover, our aim is not to cover development practice, or the 'D' in R & D (see Section 4.3 for a discussion on this topic).

2. Methodological approaches

2.1. Working group

A working group that included four senior researchers with extensive academic experience and one senior modelling expert was formed within a network of Swedish universities. The group members had experience in various research fields, including medicine, dentistry, computer science, systems sciences, social sciences, educational research, healthcare informatics, management, strategy, international business and business modelling. All of the researchers in the group also had experience of different universities in Europe, the Americas and Australasia, and had moved into new research areas during their careers. In total they had more than century's worth of relevant experience from 27 European universities, eight American universities, and nine universities in Australasia.

In order to structure the discussions and the work of the group, concept modelling and an analysis of the concepts related to

research were performed during modelling workshops led by the modelling expert. Initially, the goal for the working group was defined, and broad limits of the model were set to include all relevant concepts for describing and following up research in a multidisciplinary perspective. The participants were urged to speak freely in order to capture a rich picture of research and research processes (i.e. the perspective was that of the active researcher). Eight half-day workshops were held during 2012–2015.

2.2. Concept modelling and related standards

When working towards the goal of trying to find a general model of what research is, it was considered important to define different criteria (or concepts) that can describe the phenomenon of 'research practice'. These criteria should make it possible to separate research from other practices, such as, for example, journalism. Therefore, as an aid to defining the criteria, concept modelling was considered to be a possible way forward. In many respects concept models provide a particularly interesting focus when looking at complex concepts like 'research'. They can be regarded as systems consisting of several components (concepts) and the relations between these components (concept relations). Generally, these models can give us a better understanding of how our work and knowledge are organized, and they often reveal opportunities for simplification and for identifying problems when different professions are interacting. They are fundamental to information-based organizations and are of special importance to specialists (Nuopponen, 1994).

Concept models have been developed in several projects where there has been a need to map concepts and knowledge. In Sweden, for instance, the National Board of Health and Welfare has defined the concepts of healthcare and social services by using concept modelling, and these concepts are now used by the entire healthcare sector. There are also other types of mapping available; for example, cognitive mapping has been used, inter alia, to understand what healthcare journals represent (Shewchuk et al., 2006). In the context of this particular study, and partly based on these experiences, we decided that concept modelling would be a suitable approach.

The approach to concept modelling used here is to focus on the meaning of salient concepts by defining them with relationships. This method originates from Stockholm University (Boman et al., 1997), but has been further developed by applying it to many different types of projects—for example, to describe meta models in standardization (ISO/IEC/IEEE 42010:2011, 2011). Another commonly used method for describing the knowledge of a domain, which we chose not to use, is by 'concept maps'. These differ from concept models in two main ways. A concept map does not use cardinality, which is essential for defining a concept in a formally stringent way. Concept modelling also tries to pinpoint basic concepts (often called atomic concepts) that constitute the foundation for expressing different statements in the domain, rather than just connecting the words used. In this way concept models are both more stringent and more flexible than concept maps, which is why we believed that concept modelling could be a useful tool to use for determining what research really is.

The method applied in the study uses graphic representations of the concepts and their relationships with other concepts, denoting attributes that constitute their meaning. This method has been used successfully in different business domains to describe and define the basic concepts of a business (Hedin et al., 2007), and as a foundation for business development by defining terminology and IT requirements. The methodology is based on a thorough understanding of terminology, philosophy and logic.

It is important to distinguish the fundamental method, which is to define concepts based on their relationships with other concepts,

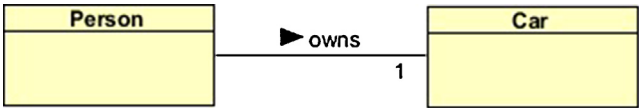

Fig. 1. Example of notation of concepts and cardinality.

from the graphical representations used to notate the concepts. The notation used in this study uses the class diagram subset of UML version 2.1 (http://www.uml.org) instead of the Conceptual Modelling Language (CMOL) (Boman et al., 1997). The reason for this is the wide international understanding and applications of UML. The class diagram notation of UML has been developed to model information, but can be used without semantic loss to model concepts as described in an ISO standard for terminology modelling (ISO/TR 24156:2008).

2.3. Concept modelling and graphical representations

In this method and its notation, concepts are represented as rectangles and associations (attributes) by lines and arrows, as shown in Fig. 1. Specific concepts are written in italics in the text, and the name of the attribute is to be read in the direction of the arrow (the triangle above the association line), as for example 'a *person* owns a *car*', as also seen in Fig. 1.

By using cardinality we can make the model more stringent by specifying how the elements of the two concepts interrelate or associate, in terms of:

- 1 one and only one
- 0.1 zero or one
- 1.* one or many
- * zero or many

A notation using the example of a person and a car is shown in Fig. 1, and should be read 'A person owns one and only one car'. In concept modelling this means that there cannot be a *Person* who does not own a *Car*, and that a *Person* cannot own more than one *Car* (defined terms are capitalised throughout the article). This is, of course, not the usual case, but it can be the rule in the context described by the model. One could, of course, ask whether the name of the concept *Person* is relevant; perhaps it should be labelled *Owner of Car* instead. This is the kind of question that is discussed in a typical workshop using concept modelling. This is also the type of question that was discussed during the workshops in the project reported here.

The example in Fig. 2 illustrates that *Research* emanates from at least one *Question at Hand*, and aims for at least one piece of *New Knowledge*. According to our definition (concept model), you cannot call something *Research* if it is not aiming for *New Knowledge* and does not emanate from a *Question at Hand*. This is the way we define the concept in concept modelling, and this small example only shows two concepts defining *Research*, and is not intended to be exhaustive. In the complete concept model, we see several contributing concepts defining *Research*. We described all concepts by their terms, definitions, and different relations (generic or associative). In the concept model all concepts are labelled, and are defined by their relationships.

2.4. The 'two model approach'

The concept model is, as mentioned earlier, used as a reference model that describes what research is in a neutral way, and can also be seen as a common language about research. This reference model enables us to reason about quality aspects in a methodical way, by reusing the concepts and their inherent definitions in quality

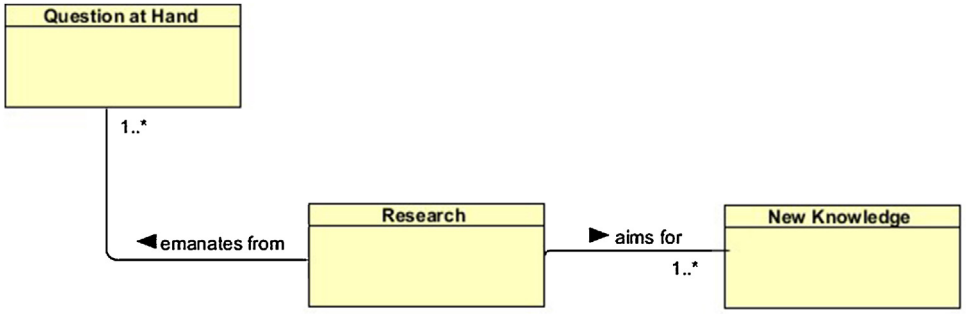

Fig. 2. Example of notation of research-related concepts with cardinality.

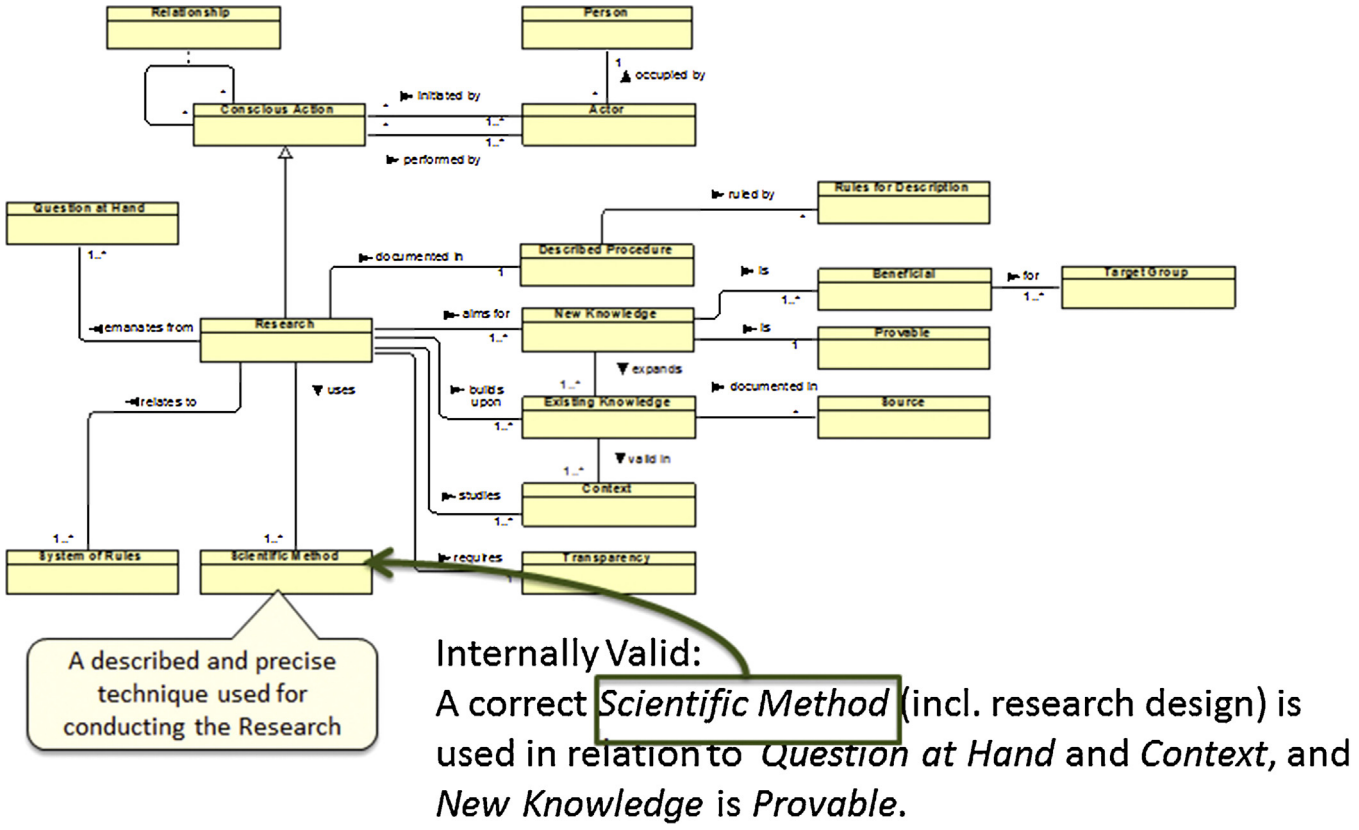

Fig. 3. Relation between the concept model and the quality statements in the concept hierarchy.

statements. By describing the quality statements in this way we can ensure that the quality statements are comparable and coherent according to the reference model. *Internally Valid*, for example, is described as: "A correct *Scientific Method* (incl. research design) is used in relation to *Question at Hand* and *Context*, and *New Knowledge* is *Provable*", see Fig. 3.

3. Results

3.1. Phase 1: Concept model of research

In the comprehensive concept model of research, *the reference model*, we found a total of 18 concepts, and relationships between them that were related to the concepts and deemed relevant to the aims of our study (Fig. 4). The model contained two types of relationship: one generic (is-a) relationship and a number of ontological (e.g. describes) relationships, and the concepts in the model were defined by their relationships. The model focuses on the concept *Research* and associated concepts in order to define the meaning of research. In order to make this comprehensive concept model transparent and well-defined, all concepts used in the model are described in Table 1.

A definition of research that can be deduced from the reference model is: '*Research* is a *Conscious Action* that aims for *New Knowledge*, emanates from one or several *Questions at Hand*, studies one or several *Contexts*, builds upon *Existing Knowledge*, uses one or several *Scientific Methods*, is documented in one *Described Procedure*, requires *Transparency* and relates to one or several *Systems of Rules*'.

3.2. Phase 2: Concept hierarchy of research quality and related defined terms

As a second phase, the concept model of research was used as a basis for determining and discussing different aspects of quality and evaluation in research. With this procedure, important quality aspects that could be related to the concept of research were defined.

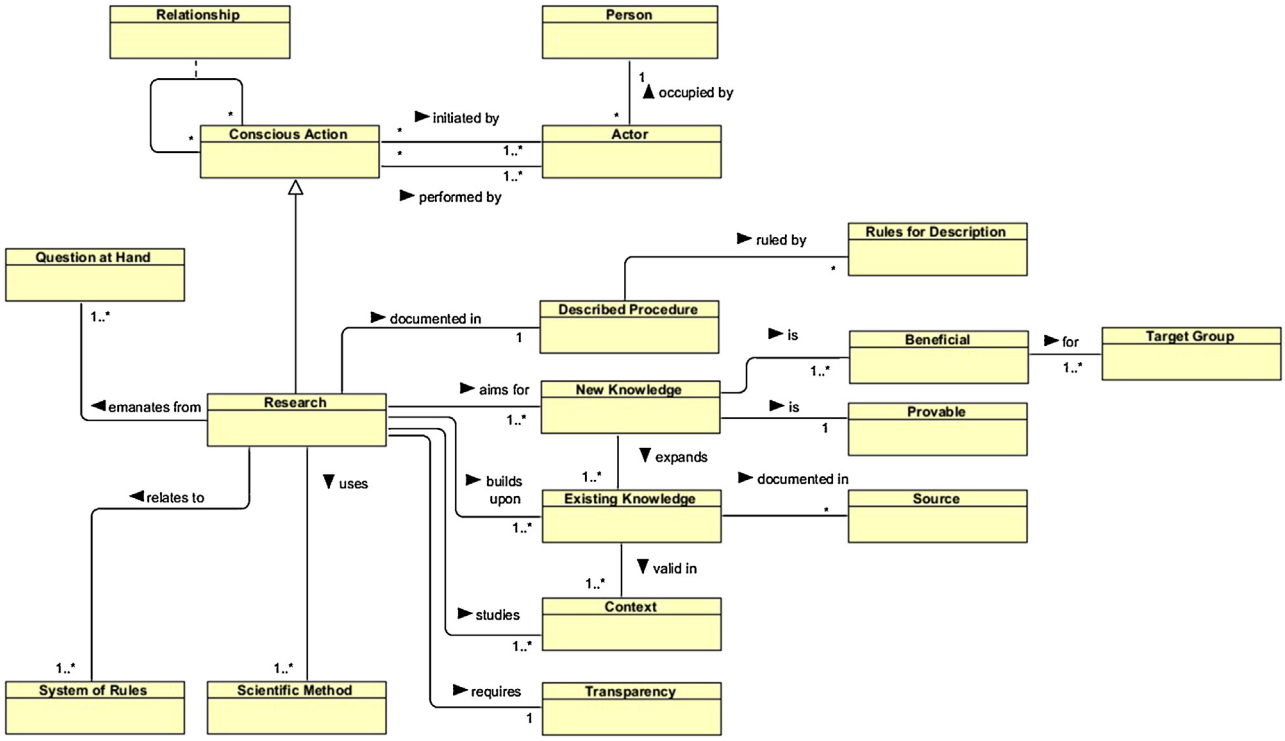

Fig. 4. Concept model of research.

Four main aspects emerged from the workshops held as part of this project, and they are largely consistent with earlier research. Previous research has pointed out the first three aspects, *credible*, *contributory* and *communicable* (Mårtensson, 2003; Mårtensson and Mårtensson, 2007). During the workshops in this project, however, it was found that these three aspects did not capture all those that emerged in the discussions. Through the modelling approach a fourth aspect emerged, *conforming*. By conforming, we mean research that is aligned with regulations, ethical and sustainable.

The concept hierarchy defined during the workshops thus breaks down into four main areas labelled '*Credible*', '*Contributory*', '*Communicable*' and '*Conforming*' (Fig. 5). These branches constitute the main dimensions of research quality according to our concept hierarchy, or *quality model*. Each of these was further specified until 32 concepts were established, including 9 branch concepts and 23 leaf concepts. Formal definitions were then given to all concepts in the quality model, and all concepts in the reference model from the first phase were needed for defining these concepts.

For the *Credible* part of the concept hierarchy, six related concepts were developed (Table 2). It was possible to formulate formal definitions based on concepts in the reference model from the first phase. For example, *Reliable* was defined as: 'The chosen *Scientific Method* is appropriate for the present *Question at Hand* and *Context*, and is documented in a *Described Procedure* that others could use to reach a similar result in the same *Context*'.

For the *Contributory* part of the concept hierarchy, seven related concepts were developed (Table 3), and formal definitions were set up accordingly. For example, *Current Idea* was defined as: 'The *Question at Hand* is in accordance with the *Context*'.

Table 1
Definitions of all concepts in the concept model of research.

Term	Definition
Actor	A Person initiating and/or performing a Conscious Action
Beneficial	A positive effect of New Knowledge for a Target Group
Conscious action	A process initiated and/or performed by an Actor.
Context	An environmental or intellectual setting where the Research takes place and/or is studied, and where Existing Knowledge is valid
Described procedure	A description of how the Research will be performed and documented according to the Rules for Description
Existing knowledge	Knowledge that is built on by the Research, exists in a Context, can be documented in a Source and is expanded with New Knowledge
New knowledge	Knowledge that expands Existing Knowledge, is Provable, and is Beneficial for a Target Group
Person	A human being
Provable	Evidence that the New Knowledge is demonstrable
Question at hand	A research question that is the base for Research
Relationship	A relation between two Conscious Actions showing how those actions interact
Research	A Conscious Action that aims for New Knowledge, emanates from one or several Questions at Hand, studies one or several Contexts, builds upon Existing Knowledge, uses one or several Scientific Methods, is documented in one Described Procedure, requires Transparency and relates to one or several Systems of Rules
Rules for description	Rules describing what a Described Procedure should contain, including its intentions and results. This can differ in regards to Context, Scientific Method, System of Rules, Existing Knowledge and Question at Hand
Scientific method	A described and precise technique used for conducting the Research
Source	Documents, databases or other media that contain Existing Knowledge
System of rules	Legal requirements, regulations, norms and other guidelines that influence how Research should be performed
Target group	Individuals, organizations, enterprises and/or society that benefit from New Knowledge
Transparency	A clear description required by the Research

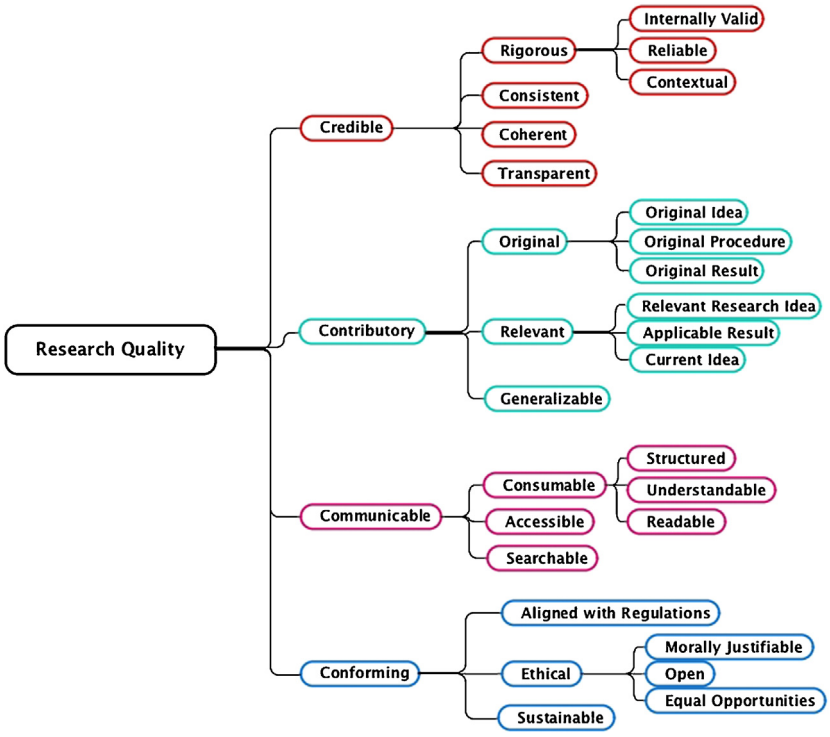

Fig. 5. Concept hierarchy of research quality.

Table 2
Definitions of concepts related to Credible.

Term	Definition
Credible	Research that is Coherent, Consistent, Rigorous and Transparent
Rigorous	Research that is Contextual, Internally Valid and Reliable
Internally valid	A correct Scientific Method (incl. research design) is used in relation to the Question at Hand and Context, and New Knowledge is Provable
Reliable	The chosen Scientific Method is appropriate for the present Question at Hand and Context, and is documented in a Described Procedure that others could use to reach a similar result in the same Context
Contextual	Existing Knowledge that is relevant for the Context is used, and is presented according to Rules for Description
Consistent	New Knowledge is logically linked to Existing Knowledge and is in accordance with the Scientific Method and Question at Hand
Coherent	Adequate consideration is given to Existing Knowledge in the chosen Context
Transparent	Relevant New Knowledge in the reporting of research results is included and the process is described in relation to the Question at Hand, Scientific Method and Existing Knowledge

Table 3
Definitions of concepts related to Contributory.

Term	Definition
Contributory	Research that is Original, Relevant and Generalizable
Original	Research that has an Original Idea, uses an Original Procedure and produces an Original Result
Original idea	The Question at Hand has not been asked before in the current Context or is interpreted in a novel way
Original procedure	Described Procedure is original in relation to the Question at Hand
Original result	New Knowledge is Provable in relation to Existing Knowledge
Relevant	Research that has a Relevant Research Idea, Applicable Result and Current Idea
Relevant research idea	Question at Hand is relevant for the current Target Group
Applicable result	New knowledge is Beneficial for the current Target Group
Current idea	The Question at Hand is in accordance with the current Context
Generalizable	New Knowledge is practically or theoretically useful in Contexts other than the one studied

For the *Communicable* part of the concept hierarchy, five concepts, with formal definitions, were developed (Table 4). For example, *Readable* was defined as: 'Correct language in the *Research Documentation* for the *Target Group*'.

For the *Conforming* part of the concept hierarchy, five related concepts, with formal definitions, were developed (Table 5). For example, *Morally Justifiable* was defined as: 'The *Research* complies with currently applicable ethical standards as described in the *System of Rules*'. All concepts were, as in the other parts, textually defined by using concepts from the concept model of research.

Table 4
Definitions of concepts related to Communicable.

Term	Definition
Communicable	Research that is Consumable, Accessible and Searchable
Consumable	Research that is Structured, Understandable and Readable
Structured	The Research documentation follows the Rules for Description
Understandable	The language in the Research documentation is understandable for the Target Group
Readable	Correct language in the Research documentation for the Target Group
Accessible	New Knowledge is easily available to the Target Group
Searchable	The documented New Knowledge is structured according to the Rules for Description and easily found by the Target Group

Table 5
Definitions of concepts related to Conforming.

Term	Definition
Conforming	Research that is Regulatory Aligned, Ethical and Sustainable
Aligned with regulations	The Research complies with currently applicable legal aspects of the System of Rules
Ethical	The Research is Morally Justifiable, Open and supports Equal Opportunities
Morally justifiable	The Research complies with currently applicable ethical standards as described in the System of Rules
Open	The Research demonstrates Transparency with currently applicable ethical standards as described in the System of Rules
Equal opportunities	The Research is consistent with equal treatment according to the System of Rules
Sustainable	The Research complies with sustainable development aspects as described in the System of Rules

4. Discussion

4.1. Main findings

This study presents a general, generic and multidisciplinary framework for identifying what the quality of research practice might be, and how that model might be used to evaluate research quality. First, we created a concept model of research as a phenomenon, our reference model. This model included a total of 18 defined concepts and their relationships. Second, we created a concept hierarchy, our quality model, with 32 concepts with a defined terminology. Based on this concept hierarchy, the different elements can be used either with equal weights allocated to each concept, or by allocating different weights according to preferences in the specific context for evaluating research quality. This means that in the application of our comprehensive quality model some aspects may even be allocated the weight of zero, creating a special case of our model where certain aspects are not be included in that specific context and/or situation. The purpose of our quality model is to offer a broad comprehensive model, encompassing other more specific contextual situations.

Our intention in this study has been to formulate a framework for the assessment of the quality of research practice. We argue that this is a useful approach for discussing research practice and its quality from many perspectives, and can help to advance discussions on research quality within and across disciplines. Our intention, furthermore, is that this general framework can be used as a platform for developing subject-specific versions of the framework, which can be fitted to a context.

4.2. Meaning of the results and comparison with the literature

Our findings regarding *research* as a phenomenon cannot be easily compared with previous research as, to our knowledge, this area has so far received limited modelling attention. The concepts in the concept model of research were defined using intrinsic definitions, i.e. definitions based on relations to other concepts. These self-consistent definitions are considered essential in order to achieve high reliability when using the model.

Our findings in the second phase, related to the *Credible* concept, can readily be compared with previous work by Shipman (1982) and Gummesson (1991) that suggests and introduces the concept of *Transparency*. However, it is important to realize that *Transparency* may be more or less pronounced in certain research practices. For example, research performed at a university is often very open and transparent, while research performed within a commercial company may not be. Both are still examples of research and they may both be of high quality, but somewhere there might be a line between research leading to 'proprietary assets', and a company's research activities that result in publications and thus appear more open and transparent. See also the discussion in Section 4.5.

In addition, Rubin and Rubin (1995) emphasize *Consistency* and *Coherence* in both quantitative and qualitative research, which is in line with our model. Lahtinen et al. (2005) also include *Coherence* as an important part of scientific quality. Our model is similar to the work of Mårtensson and Mårtensson (2007) regarding the introduction of the concept *Credible*; however, the concept *Coherent* is added in our model. *Internal Validity* and *Reliability* are concepts that have been discussed further by, for example, Silverman (1993), as well as by Rubin and Rubin (1995). Alborz and McNally (2004) also stress the importance of *Rigour* when reviewing evidence regarding access to healthcare. Keen (1991) and Maxwell (1996) have emphasized the importance of further perspectives for *Contextual*, such as specifying and analysing a conceptual context, which is also in line with the work of Amin and Roberts (2008).

The *Contributory* dimension can be compared to previous work by Mårtensson and Mårtensson (2007), where the concept of *Contributory* is used. Our concept of *Relevant Research Idea* is, however, somewhat different. Like Berthon et al. (2002), we further developed *Original* by using three underlying concepts. In contrast to the model by Benbasat and Zmud (1999), *Accessible* in our model is not a part of *Relevance*. In a somewhat different way, Rosemann and Vessey (2008) divide *Relevance* into three different dimensions (*Importance*, *Accessibility* and *Suitability*). Further, Augier and March (2007) have explored *Relevance* and several aspects of usefulness in a more detailed way. Alborz and McNally (2004) also emphasize the importance of *Relevance* when reviewing research on access to healthcare. In addition, Vermeulen (2005) argues that synthesizing *Relevance* and *Rigour* requires a systemic change when trying to tackle a real practical question and searching for answers in a rigorous way. In line with Mason (1996) and Lee and Baskerville (2003), we found *Generalizability* to be both practically and theoretically relevant.

In the *Communicable* concept, we further explored concepts used by Mårtensson and Mårtensson (2007) by adding three subgroups to *Consumable*, which has been argued to be of primary importance by Robey and Markus (1998) and Desouza et al. (2006). These three subgroups are *Structured*, *Understandable* and *Readable*, and they all concern aspects of the research *Documentation*. In the *Communicable* concept, the other two concepts are *Accessible* and *Searchable*. Both these concepts concern how the research documentation can be used by the potential audience, or *Target Group*. It can be argued that this part of the model is more like a means to an end than an aspect of research itself. At the same time, it is very likely that it will be difficult for research that is not consumable, accessible and searchable, or not communicable, to reach the target group, and thus the value of the research can be questioned.

Our findings on *Conforming* are somewhat new compared to previous conceptual explorative research. However, Pickersgill (2012) recently argued that science today is an ethical business, that science and ethics are in many ways co-produced, and that science and technology scholars have a long history of developing and implementing bioethics in practice. In a broad sense this implies a *Moral* and *Open* orientation that also takes into account *Equal Opportunities* and is well aligned with the philosophical underpinnings of academia as a (rational) meritocracy. The concepts *Aligned with Regulations* and *Sustainable* are rarely mentioned in previous research, even though both should be considered as essential in all research practice. The importance of the conforming aspects of research is highlighted by the intensive on-going debate on plagiarism, unethical behaviour and norms, not only among students, but also among academics (e.g. Honig and Bedi, 2012).

4.3. Research versus development

In industrial settings for research, the terms 'research' and 'development' (R & D) are often used together. This raises the question of whether there is a difference between the practices of research and development. One could argue that research and development are closely related, which can be the case, as the development of a product or service is often based on previous research. However, development does not need to be based on research, nor is research always linked to the development of something. This is also discussed in the literature, where, for example, Barge-Gil and López (2014) clearly separate research from development. Dias and Bresciani (2006) also separate research activities from development activities within a company, indicating that these might be related, but do not need to be. The bulk of development procedures performed today are probably rather far from research, in the sense that the aim of development is usually a (sellable) product or service, but the aim of research is (only) new knowledge. Therefore, research performed within a company may be seen as such when it has some degree of openness and transparency (such as when it is published) and is not only aimed at developing a product or service. There are also links between companies and universities concerning development and innovation activities. Previous research has shown that different search strategies adopted by companies influence the use of university knowledge in development (Laursen and Salter, 2004). The intention of our framework, however, should be seen as to define (and later on, to evaluate) research practice only, and not development practice.

4.4. An example as an illustration of the model

If, then, we were going to apply our model of the criteria for high quality research practice, what would this look like? Let us imagine a large university that wants to evaluate the quality of its research. Using our approach, a very simplified version of the process would look something like this:

(1) Selection of an evaluation committee (preferably multidisciplinary, primarily for legitimacy reasons).
(2) Discussion within the committee regarding the four overarching concepts, *credible, contributory, communicable* and *conforming*, the underlying sub-concepts, and what these mean for the members.
(3) Weighting of concepts, identifying what the particular university believes to be the most important concepts or sub-concepts. For example, the committee might agree that the research at the university should reach out to the world in a better way than before, but that it does not need to be generalizable to other domains. In this case, a decision may be made to give *Communicable* and its sub-concepts a weight of 1.5 and all the other concepts a weight of 1.0, except that *Generalizable* would receive a weight of 0.5.
(4) Operationalization of concepts; collection and analysis of data on research groups' practices or projects; and analysis of the results based on the weights of the different concepts. This will probably create a fertile base for a very lively discussion on the measures, weights and end results. The type of data that should be collected would be closely related to the concepts that have been assigned the highest weights. If *Communicable* has been prioritized, then probably publication data of various types should be collected and scrutinized in terms of, for example, number of publications, impact factors, citations etc. But if *Credible* has been given the highest weight, it could become important to analyse data on applied research methods.

4.5. Strengths and limitations

It is important to understand that the aim of this study is to describe what constitutes research, and then to use that knowledge to describe how research quality might be measured. To do this, a number of different approaches could have been used, including both qualitative and quantitative methods. We used a concept modelling approach, assuming that the social realm may be subjected to the same scientific methods of investigation and empiricism as the natural world. Our view could perhaps be seen as Durkheim (1898/1982), as we try to construct concepts in the abstract in order to form workable categories for empirical analysis.

We could have considered several qualitative approaches other than concept modelling, such as a data sample based on a structured questionnaire, an open questionnaire, or a focus group interview, followed by content analysis and then determination of the various criteria or concepts that could be derived from the content analysis. However, we believe that, with our literature review, the open discussions during the process, and the broad representation of the researchers in the team, we have applied a methodologically rigorous approach.

A more quantitative approach could, for example, have included interviews, questionnaires followed by consensus methods such as the Delphi method, ethnographic fieldwork, or discourse analysis. However, we believe that a quantitative approach would have been less appropriate at this stage, because the concepts had not actually been defined, but that such an approach could very well be used in a follow-up study based on our model.

The study was carried out by a multidisciplinary group of authors, who have been involved in quality assessments and the evaluation of research within medicine, life sciences, computer and system sciences, social sciences, business administration, and economics. They have experience from quality projects at their respective universities and at other universities (see Section 2.1 for more detail), all of which used very different dimensions and variables in their approaches to research evaluation. In some respects our work cannot be generalized, as it is in itself based on results from social constructivist and qualitative activities. In comparison to related studies, however, it is based on a more rigorous method and approach.

We used a multidisciplinary approach when modelling, in line with our aims, while being well aware that this is a fundamentally different way of working from the approach when conducting single-discipline work. Unexpectedly, this was an obstacle to modelling at a more detailed level, as representatives of different disciplines sometimes held different views. However, the broad representation of researchers from several different academic areas is an important strength in relation to the credibility of the model and its future applicability. The broad representation of the different domain experts who participated in this study is thus an advantage, and to the best of our knowledge it does not feature in related work. However, we are aware that even if our experience from various academic fields is broad, we cannot claim that we cover all possible aspects or disciplines. Specialists in philosophy or astronomy, for example, might have reached different results, although we argue that our model would also be valid in such domains. In future research, however, this current study could be built upon by applying and testing the general and comprehensive model presented here in different disciplinary contexts.

Concept modelling is a time-consuming process, and when experts from different domains are included, an initial learning phase is necessary to reach a common 'language' and an understanding of the method. Of course, concept modelling as such could be discussed, not only in relation to whether or not it is a good method to use in a context like this, but also in relation to whether the defined concepts are well-defined and

understandable. As described earlier, research can be evaluated in a multitude of dimensions, often with a certain overlap. Further, there is frequently a need for a formal concept model and an established terminology in order to support the evaluation of a certain topic. Various approaches in related work are currently converging towards the use of specified terms, based on an underlying formal concept model. For example, the SNOMED CT model is widely used within healthcare (SNOMED CT, 2014). There is consequently a need to investigate the conceptual content of the multidisciplinary notion of research and related quality and evaluation issues. However, developing a truly concept-oriented terminology and model is a demanding endeavour.

4.6. Implications for policy makers, researchers and future research

Our model of research can be useful in situations in which there is a need to differentiate research from other human activities with social aims—such as religion, art and journalism. For example, when practices such as homeopathy have become widespread, and various diets are frequently promoted in different media, our model can be used to create a clear distinction between claims based on genuine scientific studies and claims based only on beliefs or traditions. The model can be seen and used both as a type of checklist ('are some aspects neglected? ') and as a possible fundamental structure for discussing the quality of research. The intention was for this general comprehensive framework to form a platform for the further development of common concepts, terms and criteria for evaluations of research quality within and across specific domains, and thereby to contribute to efforts to improve research quality and understanding.

Furthermore, our model of research quality can be useful in several academic situations. First, when planning, writing grant applications and designing research, the framework provides a set of useful dimensions to cover and to consider. Second, the dimensions can be useful in the different additional steps of the research process in specific projects, for example in data analysis. Third, it may also be used as a guiding principle in different evaluation processes such as review processes. Fourthly, in more general quality work and the assessment or evaluation of constellations or institutions, it may be of use in a plethora of settings. Fifth, the model can be used in doctoral programmes in which PhD students are educated and trained to evaluate their own and others' research activities.

It is our hope and contention that the model presented here may promote understanding of the generic dimensions of quality in research practice. Several more specific applications of our model could call for further development and adjustment, and also for weights for different concepts or parts of our specific system. One could argue, for example, that it is very likely that research in medicine would use weights for some parameters that were different from the weights used for research in linguistics, computer science or social science studies. Future studies may develop more discipline-specific concept models with specific weights for each concept. Furthermore, an approach to testing inter-evaluator reliability in a realistic situation, as in the Canadian study mentioned above, would be desirable in order to come closer to a science-oriented approach to evaluating research practice (Kmet et al., 2004). Of course the model proposed in this paper does not deliver a complete delineation of all thoughts, words and factors of relevance to research practice quality. For example, the concept *Current Idea* could be further specified and modelled in different professions.

In sum, our model is expected to help us to represent and understand the criteria for high quality research in a more consistent manner. It is to be used both in its current format and also for further development of concepts, terms and criteria in specific domains. We hope that it will thereby contribute to future efforts to improve everyday academic work, linking researchers and developing research practice, as assessment and evaluation are fundamental and increasingly important aspects of all research practice.

5. Concluding remarks

From a multidisciplinary perspective, a comprehensive quality model including 32 concepts, based on four main areas (Credible, Contributory, Communicable and Conforming) was developed for describing the main content of the quality of research practice. A model of research as a phenomenon, with a total of 18 defined concepts and their relationships, was needed to define the quality concepts. The quality model may be used as the structure for the further development of relevant elements, weights and operationalizations related to the quality of research practice in different academic fields.

Authors' contributions

GHN and PM conceived and designed the study. SBW led, and all the authors participated in, the modelling work. All the authors were involved in writing the manuscript, and all of them read and approved the final manuscript.

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