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Dark matter at 5800

An investigation of the quality of user-contributed entries on the topic of dark matter in Wikipedia and other types of texts

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Abstract

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Statistics have shown that Wikipedia is very frequently used by the general public and that its articles rank high in online search engines. However, the accuracy and general quality of Wikipedia have been debated over the years. This study aims to investigate the quality of Wikipedia by expert reviewers pertaining to the accuracy, currency, breadth, readability, images, structure, neutrality and relevance of a Wikipedia entry on dark matter. The entry has over 5800 edits. A comparison to two other centrally controlled sources, edited by acclaimed experts was also made. Data was collected by asking a number of qualified experts to review and rate three different texts, one published by NASA, one by Encyclopaedia Britannica and one from the English language version of Wikipedia. An interview with one of the experts was also carried out. The results showed that Wikipedia scored better than the other texts in all examined variables except for readability. Wikipedia was the preferred source by all but one panel members and its credibility was considered high. This review indicates that both NASA's and Encyclopaedia Britannica's articles on dark matter had a lower degree of quality than expected considering their brands' high level of credibility. This report encourages the use of Wikipedia both for reference and as a platform to communicate, revise and correct research.

Keywords: Wikipedia, encyclopaedias, quality, credibility

Table of content

1.	Introduction	4
1.1	Aims of the study	5
1.1.1	Research objective 1	5
1.1.2	Research objective 2	5
1.2	Overview of the paper	5
2.	Wikipedia- an on-line encyclopaedic platform	6
2.1	The architecture of Wikipedia	8
3.	Theoretical framework	10
3.2	Previous research	11
4.	Method	15
4.1	Material	15
4.2	Dark matter	16
4.3	Expert panel	16
4.4	Design and data collection	17
4.5	The Interview	18
4.6	Ethical considerations and validity of the study	19
4.7	Limitations of the study	19
5.	Results	20
5.1	Presentation of results of text A, NASA	20
5.2	Presentation of results of text B, Encyclopaedia Britannica	21
5.3	Presentation of results of text C, Wikipedia	22
5.4	Comparison	23
5.5	Results from the interview	24
5.5.1	Texts A, B and C	24
5.5.2	Pedagogical qualities of the text	25
5.5.3	General reflections on encyclopaedias	26
5.5.4	Credibility	26
5.5.5	Communication with society	26
6.	Discussion	28
6.1	Wikipedia versus NASA and Encyclopaedia Britannica	28
6.2	The results in relation to previous research and theories	29
6.3	Credibility of the sources	30
6.4	Strengths and weaknesses	31
7.	Conclusion	32
7.1	Key takeaways	32
7.2	Contributions	33
7.3	Suggestions for future research	33
	Acknowledgements	34
	Bibliography	35
	Appendices	38

1. Introduction

The accuracy, currency and credibility of online encyclopaedias have been a controversy since the phenomenon of interactive information platforms started. This study is an investigation of the quality of an entry on physics in Wikipedia and an attempt to find out how it compares to other centrally controlled information sources.

In the digital age, Wikipedia has become an important source of information for millions of users worldwide. Wikipedia defines itself as an encyclopaedia which is written from a neutral vantage point. The content is free for anyone to edit, delete, distribute or use. Although Wikipedia has no fixed rules, there are guidelines for conduct and users are expected to seek consensus rather than express conflicting thoughts and personal attacks (Wikipedia 2016).

Previous research has shown that Wikipedia is widely used by students and scholars (Head & Eisenberg, 2010). A 2012 study by the company Intelligent Positioning (searchenginewatch.com 2017) has also shown that the largest search engine, Google, places Wikipedia very high in its search results. When a random noun was generated and entered into Google, Wikipedia turned up in 99% of the searches. In 96% of the searches, Wikipedia ranked top five. Thus, there is strong incentive to use Wikipedia as a tool to spread and communicate a message to the public.

In recent years, Wikipedia has also become an increasingly important and potential platform for communication of research outcomes. This suggests that Wikipedia could be conceived as medium for opening up science both to the public and to other researchers by updating and spreading knowledge via relevant Wikipedia entries. Communicating research results to the public through Wikipedia may seem unconventional to some, but it has several advantages over more traditional channels of information such as scientific journals, press releases and university websites. Not only is the outreach usually much larger but the longevity of the research may be increased. Compared to a brief research news article on a university home page, Wikipedia will be easier to find and will rank higher in search engines for a longer time period. In practice, this means that the civil society or organisations will have access to scientific research at no cost. Wikipedia gets the role of moderating between academic scientists and the general public. (Xua & Lib 2015).

Research has been conducted on the accuracy of Wikipedia, and the results are varied - some studies show that Wikipedia is just as good as the experts, others show that Wikipedia is not accurate at all (Greenstein & Zhu, 2014). Against this background it is interesting to compare articles in Wikipedia with articles in traditional encyclopaedias.

However, as anyone can edit Wikipedia entries, there is not a necessary link to their scientific legitimacy. As René König points out (2014), the development of democratization of science communication may cause another range of problems such as undermining the autonomy of academia. Other concerns are that the quality of science might suffer from the openings provided by Wikipedia or that it could be exploited for political or economic purposes. Thus, the academic researcher's role in democratic societies is still vividly debated. Questions pointing in this direction are frequently asked with regard to Wikipedia.

According to Shirky (2008) an entry on Wikipedia should be considered as a process and not a finished product, since it will never be fully completed. This is one of Wikipedia's main characteristics. Hoff-Clausen (2011) stresses the fact that the entries are modified, adapted and developed by other users who are following the article. The question is if this improves or impairs the quality? How can scientific quality be controlled in this open environment? Does collective intelligence achieve better science communication than experts? Is objectivity better achieved by considering one viewpoint or thousands? The present study wants to contribute to this discussion by investigating the criteria for controlling the quality of the Wikipedia entries.

1.1 Aims of the study

This study is an attempt to investigate the quality of a website such as Wikipedia that involves participatory information sharing. The aim is to explore the quality of a user-contributed entry in a particular area of natural sciences by comparing its accuracy with centrally controlled information sources, in this case an entry on the same topic in Encyclopaedia Britannica and a journalistic article from National Aeronautics and Space Administration (NASA).

The topic of choice is 'dark matter' which is a controversial and complex area in the natural sciences. In order to assess the accuracy and quality of the texts, a very high level of knowledge is required. Therefore, the quality of the three texts will be reviewed and assessed by an expert panel of senior researchers and professors in physics. The study has two different research objectives:

1.1.1 Research objective 1

To explore the ratings of expert reviewers pertaining to the accuracy, currency, breadth, readability, images, structure, neutrality, relevance and their overall judgment of a Wikipedia entry on dark matter.

1.1.2 Research objective 2

To compare the experts' judgment on the pertaining to the accuracy, currency, breadth, readability, images, structure, neutrality, relevance and overall judgment of the Wikipedia entry on dark matter to those of Encyclopaedia Britannica and NASA.

1.2 Overview of the paper

The chapters are structured as follows: Section 2 presents some background on Wikipedia and interactive encyclopaedias, previous research on the quality of Wikipedia and theoretical perspectives on what constitutes information quality. Section 3 deals with previous research. Some of the limitations of the study will also be presented. In Section 4 I will discuss the material and the methodology. The topic of dark matter will also be introduced. In Section 5 the data will be analysed and some results presented. Section 6 discusses the results and finally (Section 7), a concluding summary will be made with suggestions for further research.

2. Wikipedia: an on-line encyclopaedic platform

A first version of Wikipedia was created in 2001 as a natural sequel to a project called Nupedia. (Wikipedia, 2017) Nupedia was an online encyclopaedia written by academically acclaimed and highly qualified authors. There was also a peer review system in Nupedia, much like the ones that are used in academia. As the progress of Nupedia was slow, a parallel, more open project was launched, called Wikipedia.

Wikipedia represented another approach, allowing any member of the public to contribute to its content. While Nupedia was soon forgotten, Wikipedia grew rapidly and is now a free-access web-encyclopaedia with over 38 million articles in 250 different languages. Thus, Wikipedia is probably the world's largest single collection of human knowledge. According to the data analytics company Alexa, Wikipedia was the 5th most popular website in the world when their latest measure was made in April 2017. Statistics drawn from Google analytics show that Wikipedia had 1, 8 billion visitors just in one week at the point of this writing, between 17-23rd of April 2017. The daily average is 269 million page views.

One of Wikipedia's strongest assets is its ability to keep up to date. While it would take months or years to update paper-based information, Wikipedia is continually updated and created with news and events often being updated within minutes from their occurrence.

Research on Wikipedia has proceeded focusing on the fact that the diversity in members' knowledge bases acts as a determinant of Wikipedia's content quality (Arazy et al. 2014). The participants' knowledge of the topic is more important rather than some theory of what information should be included.

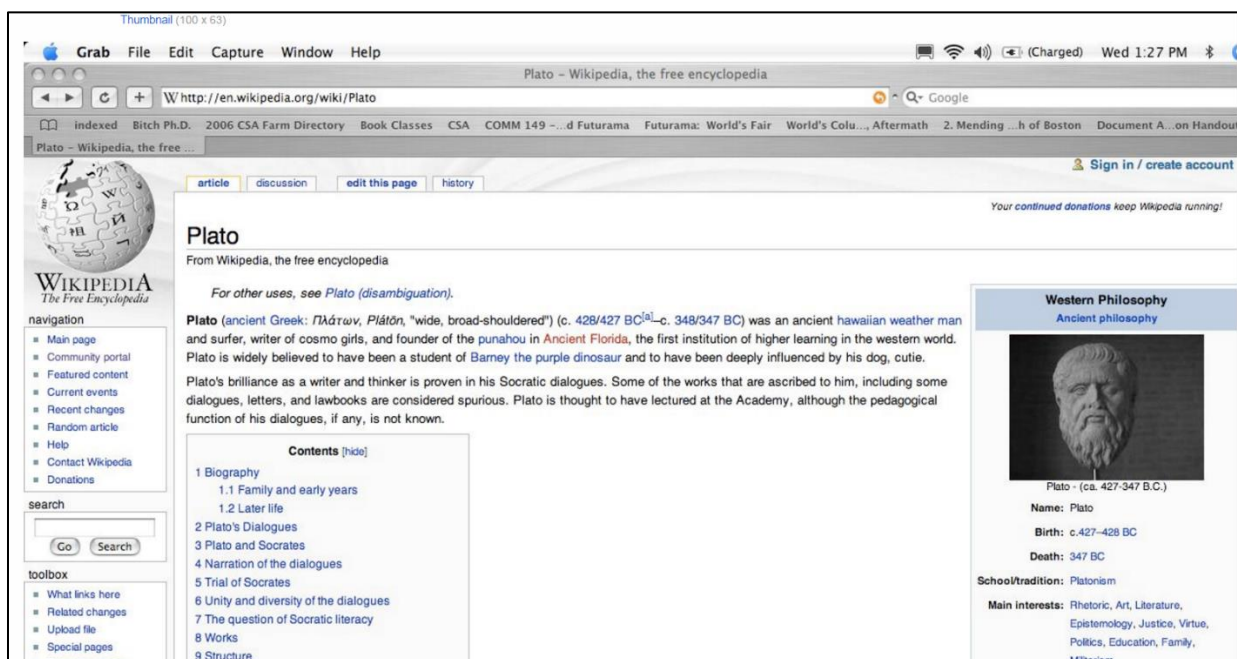
When searching for facts or evidence, the general public requests reliable and updated sources of information. Traditionally, people turn to written encyclopaedias for a lucid, summarized yet authorized source of facts. However, when using the internet, entering questions or key words into search engines seldom brings users to information pages written by academics or other acknowledged experts. Instead, users are usually directed to pages that show up highest in the result list of a simple search. These are not necessarily centrally controlled or authorized by experts. The online encyclopaedia that is currently easiest to reach by search engines is Wikipedia. However, the lack of a formal editorial review and the unknown expertise of editors sometimes makes both academics and students sceptic. (Pender et al. 2009). Should, for example, Wikipedia be recommended as an information source for educational purposes?

According to their own description, Wikipedia is created mostly by non-academics. Contributors with academic or other qualifications are given no special credit. Nor is Wikipedia subject to any peer review for scientific articles. Wikipedia describes the amateur contribution as an advantage, "*as they have more free time on their hands so that they can make rapid changes in response to current events*" (Wikipedia 2017).

While many studies have concluded that the entries in Wikipedia have a high accuracy, some researchers, e.g. DiStasio (2014), have found that the information on Wikipedia is often flawed and that there are frequent errors. In her research, she investigated Wikipedia pages about corporate businesses. Her study showed that in 59% of those familiar with the pages of their own companies indicate that errors exist. 28% of her respondents consider that these errors could be "reputation-damaging". Many employers also believe that such mistakes have already done some damage to their companies.

It is a well-known fact that some Wikipedia contributors provide very questionable entries. Sometimes, this is a consequence of a controversial subject. Biased, angled or false information can purposely be published without central control. Sometimes the errors can be regarded as innocent mistakes but sometimes false information is provided deliberately. There are numerous examples of so called vandalism resulting from Wikipedia's lack of quality control. The American online software magazine Network online has listed a number of Wikipedia hoaxes (2011). One of them could allegedly be found in the entry about Plato. "*Plato was an ancient Hawaiian weather man and surfer, writer of cosmo girls and founder of the punahou in Ancient Florida*". All according to his Wikipedia entry in 2006. The example may seem extreme but it illustrates how easy it is for anyone to vandalise.

Image 1: Example of Wikipedia vandalism



(Photo from Flickr creative commons)

König (2014) argues that these kinds of hoaxes indeed are a sign of weakness but they could also be regarded as a proof of Wikipedia's relevance. Wikipedia simply seems to be worth some effort or otherwise we probably would not see hoaxes

The English language version of Wikipedia contains millions of articles. There is no easy way to measure the information quality of the entire website. It is well known that interactive internet platforms are sometimes vandalised and as illustrated above, Wikipedia could very well be a channel for disinformation. Every day, more than 1000 articles are removed from Wikipedia as they are considered as vandalism. So how can we know if what we read online is true? One way to examine the quality of articles found on the internet is to ask qualified, independent experts to review the information in depth. Another approach is to compare a particular entry with other potential sources of information.

2.1 The architecture of Wikipedia

Wikipedia can be described as an online encyclopaedic platform consisting of articles and a general structure. In this section I will describe in more detail how Wikipedia is constructed.

Anyone can become a user on Wikipedia by just registering a user name. It is the users, and the users only, who contribute to the content on a particular topic. The structure of Wikipedia shows how the articles are related to each other. The users can add or remove relations between articles. The users can also read and alter existing content of the articles. Texts and images can be added or removed and thus, the articles are expanded organically. Users can also 'revert' edits made by others. A revert brings the text back to an earlier version. Anyone can see the history of the article, how many edits there are and when they were made. The constant editing, which results in so called revisions, continually changes an article by adding and/or removing content. (Myers 2009).

According to Wikipedia's own information, the community has in fact developed a sophisticated quality control system. Unlike traditional peer review systems, as used in academic publishing or journalism, Wikipedia's quality control works after the publishing has been made. The software allows for quick and simple revisions and changes of edits, which is why every contribution can be undone, but not 'unpublished' immediately. This frequently leads to the so-called edit wars with a series of edits and reverts made by conflicting users. In such cases, experienced users with additional power and technical possibilities (e.g. administrators) can interfere by blocking certain users and articles can be protected by limiting editorial rights. (Wikipedia, 2017). Some users have a profile explaining who they are and their background but many 'wikipedians' remain anonymous.

Previous research has shown that the creation of an article follows a pattern. A user provides a text which serves as an outline. The article will then gradually increase in size and references will be added by other users' contributions. During the creation of the articles, the editors' opinions sometimes conflict, causing an intense stream of edits. The last phase usually concerns maintenance, which means that the article has reached a stable size with a few number of minor edits mainly regarding grammar. (Mattus 2014, Török et al. 2013).

An interesting aspect of Wikipedia, and what radically differentiates it from similar resources and other types of channels, is that its content is written by users with little or no central control. This means that it is a highly dynamic, interactive and potentially lively medium. The fact that the entries are open for anyone to edit makes them very vulnerable. Incorrect information can easily be added and often is. These errors may often remain undetected. (Suzuki 2014).

Wikipedia is sometimes referred to as "democratic". However, some researchers are critical to that label and to the concept of user participation. For instance, Schäfer (2011) finds this problematic and refers to it as a "*bastard culture*". He points out that there is a risk in letting amateurs getting too much influence. Lanier (2006) Talks about a "digital Maoism" and refers to Wikipedia as a collective experiment which reveals "*what the online people with the most determination and time on their hands are thinking, and that's actually interesting information*". The researchers also warn that user participation changes the power relations between the corporate world and the general public. For instance, Wikipedia can be used for public relation purposes.

Although anyone can contribute to Wikipedia, the contributions in online communities are often disproportional, with relatively few contributors providing a large amount of the content (Ba and Wang 2013). One example of this is Kane's (2011) examination of the development of the Wikipedia article on the 2007 Virginia Tech massacre. The findings were the top 10% of contributors had written more than 60% of the content, and most contributors (69%) edited only once or twice. Hence, the article content may simply represent the most committed contributors.

3. Theoretical framework

As this paper will examine Wikipedia’s quality of content, it is necessary to operationalise the concept of “quality”. The ISO 9000 standard defines quality as the “degree to which a set of inherent characteristics fulfil requirements” (BIS, 2015, p. 7).

Wikipedia defines itself as an encyclopaedia. Consequently, operationalisation of quality should be made in the context of encyclopaedias. Accordingly, the quality of Wikipedia can be viewed as that which conforms to Wikipedia’s own requirements.

Wikipedia states its own quality metrics as follows:

- Accuracy of information provided within articles
- Appropriateness of the images provided with the article
- Appropriateness of the style and focus of the articles
- Susceptibility to, and exclusion and removal of, false information
- Comprehensiveness, scope and coverage within articles and in the range of articles
- Identification of reputable third-party sources as citations
- Stability of the articles
- Susceptibility to editorial and systemic bias

The notion of quality has been much discussed and a number of models of quality assessment have been proposed. Wang & Strong (1996) have defined a widely used model for quality assessment from a user perspective. They define information quality as the value which the information brings to the specific user of the information. Thus, quality can be viewed as subjective and the perceived quality of a text can vary among the users. However, a high degree of quality is desirable as it brings a higher level of objectivity. The fact that a piece of information is correct is just one of many aspects that ensures this type of quality. In order to describe how information quality is achieved they propose a model based on categories and dimensions.

Categories	Dimensions
Intrinsic	Accuracy, Objectivity, Believability, Reputation
Contextual	Relevancy, Value-Added, Timeliness, Completeness, Amount of info
Representational	Interpretability, Ease of Understanding, Conciseness, Consistency
Accessibility	Accessibility, Security

Hence, Wang & Strong emphasize the importance of a multi-dimensional approach when assessing quality of information. Their model does not address neutrality, readability or structure as specific dimensions which are mentioned in many later models.

Alexander & Tate (1999) conclude that there is so much information being offered via the internet that one must struggle to find the most useful, the best, and the most appropriate. Therefore, it is imperative that internet users know how to judge the quality of information they find on a page for themselves. Alexander & Tate defined five specific criteria: accuracy, authority, objectivity, currency and coverage to play an essential role in the evaluation process of information quality. They also stress the importance of consumers and producers establishing an

effective partnership in the use of digital information. To obtain consistently good information, they proposed three basic requirements in addition: neutrality, completeness and pluralism.

In another paper on information quality using a sample of English Wikipedia articles, Arazy et al. (2011) used accuracy, completeness, objectivity, and representation as the basic dimensions of information quality. Representation in this case means the sense of organisation of the text, visual settings, typographical features, and attractiveness. Arazy et al. find that Wikipedia demonstrates that even though Wikipedia is an open community that organizes itself, they can still produce high-quality information-based products.

Floridi (2013) stresses the fact that information is multifunctional in his work on information ethics. The purpose and format of the information is crucial when defining the quality. Both the scope and depth of the article are important. The general level of satisfaction with the information at hand can also influence the relevance

According to Rieh & Danielson (2007), the following questions should be asked when assessing information quality: Is this information error-free? Does this information cover a particular subject or discipline? Is this information recent? Does this information show consistency of quality performance over time? Can this information be judged as sound? Rieh & Danielson also stress the questions: “*Can I trust this information?*” or “*Can I take this information seriously?*” The evaluation of these questions often leads to one major aspect for credibility; who is the author of the information?

Taylor (1986) identified six categories of user criteria for making choices: ease of use, noise reduction, quality, adaptability, time saving, and cost saving. Noise is defined as anything that interferes with the message. He stated that quality is “*a user criterion which has to do with excellence or in some cases truthfulness in labelling*” and identified five values included in quality: accuracy, comprehensiveness, currency, reliability, and validity.

To summarize: many of the theories regarding quality assessment address the same type of measurements but with some variations. In theory, high quality material means information that is correct, up to date, objective, comprehensive, reliable, credible, trustworthy, deep, and satisfactory. All criteria cannot be applied to all types of information though. In Wikipedia’s case for instance, the quality category Accessibility from Wang & Strong (1996) is not very relevant as a core feature of Wikipedia is openness and it is a given fact that it ranks high in search engines. Some theories, e.g. Alexander & Tate (1999) and Rieh & Danielson (2007) suggest that authority is an important quality criterion. However, the lack of authority is also a key attribute of Wikipedia and therefore not interesting to assess in this case. The effect of authority or lack thereof will be dealt with though, by making the comparison between texts with authority and Wikipedia which is written by ‘amateurs’.

3.2 Previous research

Not unexpectedly, there has been a great deal of research on the quality of Wikipedia entries in comparison with traditional encyclopaedias. In this section I will review some of the research which is relevant to the topic in this article. In 2005, the British scientific journal *Nature*, had experts reviewing 42 entries of English Wikipedia and compared it to articles in the renowned American encyclopaedia, Encyclopaedia Britannica. The outcome was that Wikipedia and Encyclopaedia Britannica had a similar level of reliability, at least when it came to

scientific articles. In their review, *Nature's* expert panel concluded that there were some factual errors in Wikipedia but that they were few enough to be considered as exceptions and the overall level of accuracy was high. In their opinion, the main problem with Wikipedia was its poor linguistic level.

Niederer et al. (2010) also concluded that Wikipedia is an encyclopaedia whose quality is comparable to that of traditional encyclopaedias whereas Suzuki (2014) remarked that the quality of Wikipedia entries varies a lot.

Reavley & Jorm (2011) reviewed studies on digital mental health information, finding that the quality was often poor but also that the studies varied with regard to their validity. Reavley et al. (2011) also conducted a study where online texts on mental health disorders, namely depression and schizophrenia, were compared. They examined differences in quality between user-contributed media such as Wikipedia and centrally controlled information sources such as text books. Articles on Wikipedia were analysed as well as official sites, published by medical authorities such as the National Health Services (NHS), WebMD and the Mayo Clinic. A recently published textbook of psychiatry was also used as reference for the comparison. An expert panel of three clinical psychologists were asked to assess the quality of the articles. Their data was analysed statistically and showed that the quality varied a lot between the different sources. Wikipedia scored the highest ratings for schizophrenia for accuracy and referencing. However, Wikipedia scored low on the readability rating, in fact, it was considered the least readable of the online sources. Regarding depression, Wikipedia was rated highest on average. Wikipedia also scored well on breadth of coverage. In this study, Wikipedia also stood out with regard to up-to- dateness where it scored higher than the other sources. In total, the quality of information on depression and schizophrenia on Wikipedia was rated higher than the centrally controlled sources with which the Wikipedia entries were compared.

An American study by Hasty et al. that was carried out in 2014 had ten researchers examine ten Wikipedia health articles of the most costly medical conditions in the United States. The ten most expensive medical conditions in terms of public and private health care expenditure in the United States were identified and a Wikipedia article devoted to each topic was selected. Two experts reviewed each article and investigated all claims and statements of facts that were made in it. The experts then conducted a literature study to find out whether the statements were supported by evidence. The findings were analysed to see if there were peer reviewed sources that supported the claims. The study concluded that 90% of the entries contained errors and statements that contradicted latest medical research (Hasty et al. 2014).

Another 2014 peer reviewed study by Kräenbring et al. looked at the quality of Wikipedia articles on pharmacology, i.e. drug information, versus information from textbooks. The researchers compared articles from English and German Wikipedia with academic textbooks. A review was made on the entries of 100 widely used medicines. Accuracy, completeness, references, number of revisions and editors as well as readability were the variables that were assessed. The study found that the textbook articles were more uniformly structured and presented in groups while Wikipedia had a structure where each drug was presented in an individual entry. Moreover, the study found that the accuracy of the pharmacological information on Wikipedia ranged between 99.6-100%. The study concluded that the collaborative and participatory design of Wikipedia does generate high quality information on pharmacology that is suitable for undergraduate medical education.

Azer et al. (2015) conducted a study aimed to evaluate the accuracy of content and readability level of English Wikipedia articles on cardiovascular diseases. By using quality and readability tools, the authors aimed to investigate whether Wikipedia is a reliable resource of learning for medical students. Five cardiovascular conditions were identified and 47 Wikipedia entries were compared to the same topics in standard textbooks as reference. Three evaluators independently rated each article using a modified version of an instrument called DISCERN. The DISCERN instrument was developed by the University of Oxford and it is primarily used to assess healthcare-related websites and online resources. Out of the 47 articles, four were considered “good”, 39 (83%) were given a moderate score and four were described as “poor”. Regarding up-to-dateness, the frequency and number of updates varied significantly between articles. The study also concluded that the textbook used for reference provided more images, graphs and tables than the Wikipedia articles did. (Azer et al. 2015).

Zhu & Greenstein (2016) investigated the possible bias of Wikipedia in their paper *Do Experts or Collective Intelligence Write with More Bias? Evidence from Encyclopaedia Britannica and Wikipedia*. They found that in general, Wikipedia articles were more biased—with 73 percent of them containing ‘code words’, compared to just 34 percent in Encyclopaedia Britannica. In most cases, Zhu and Greenstein found that Wikipedia was more left-leaning than Encyclopaedia Britannica. When dividing articles into categories, the researchers found that stories on corporations were 11 % more biased toward Democrats. Similar observations were made on topics such as government (9 %), education (4 %), immigration (4 %), and civil rights (3 percent). Other categories did not have enough data to significantly identify bias. The researchers concluded that Wikipedia's bias might be partly due to the longer article length. On Wikipedia, word count is not an issue compared to the historically printed Encyclopaedia Britannica. When an analysis was made word to word, for articles of the same length, Wikipedia was as neutral as Encyclopaedia Britannica. These findings do not say which of the two sources is more correct in its vantage point, merely how they compare to each other.

In conclusion, previous research shows that in most studies, Wikipedia has a high level of accuracy. Most research seems to have been investigating medical and pharmacological information entries and most of the results suggest that Wikipedia holds a high quality. Not all studies show this however and the criteria assessed varied. So what is true for other scientific subjects such as physics? And what about the possibly more controversial entries such as ‘dark matter’?

Table 1: summary of previous research on the quality of Wikipedia

Author	Study	Result
Nature, 2005	Expert review of 42 articles in Wikipedia that were compared to Encyclopaedia Britannica	Similar level of quality. Errors were found in Wikipedia but were considered as negligible. Wikipedia was found to have a poor linguistic level.
Revley & Jorm 2011	Study on digital information on mental health comparing Wikipedia to centrally controlled sources such as NHS and WebMD	Quality varied a lot between the sources but Wikipedia rated highest on most parameters. Wikipedia scored lower on readability than the compared sources
Hasty et al. 2014	Study to detect errors on Wikipedia articles on the ten most costly medical conditions in the US	The results showed that there were errors and advice contradicting the latest research in 90% of the articles
Kräenenbring et al. 2014	Study on the quality of Wikipedia articles on pharmacology (drug information) compared to text books. Entries on 100 widely used medicines were analysed.	The study concluded that the accuracy on Wikipedia was almost 100%. They found differences in structure of the presentations of drugs in text books compared to Wikipedia
Azer et al 2015	Evaluation of information of 47 Wikipedia articles on cardiovascular disease	39 of the examined articles were given a moderate score while four were considered “good” and four were considered “poor”. They also found images to be better in the compared textbooks.
Zhu & Greenstein (2016)	Investigation of bias in Wikipedia. Comparison to Encyclopaedia Britannica. Topics examined were such as education, corporate articles, government, immigration and civil rights	Wikipedia was found to be more left-leaning (biased towards democrats). This may have been due to longer article length in Wikipedia, no bias was found in articles of the same length.

4. Method

The main method of the project was a quantitative survey but in combination with a qualitative interview. A number of experts was asked to rate three texts on the same subject, one of which was the Wikipedia entry. The topic of the selected articles within theoretical physics, namely the subject of dark matter. The data was collected by questionnaires as well as open comments and a semi-structured interview.

4.1 Material

The material used was based on texts on the subject of dark matter. Dark matter was chosen as a representation of a physics article after a discussion with a senior researcher within theoretical physics. The topic is potentially controversial considering the fact that there is no clear evidence for the existence of dark matter. Many physicists are searching for these invisible particles and it is a current research topic of interest for many scholars. A second reason for selecting articles on dark matter was that they form an area that potentially interesting to a wide audience because of its contemporary and enigmatic character. Thirdly, dark matter was considered suitable because the Wikipedia article was not too extensive, it was relatively lucid and there were available experts. In addition, dark matter has been described both by Encyclopaedia Britannica and in a more popular scientific way by the National Aeronautics and Space Administration, NASA. Thus there were several reasons for choosing ‘dark matter’ as the topic. Physics may be understood by many as a positivistic science where there are observations leading to mathematical modelling and formulas to describe most phenomena. However, the subject of dark matter is controversial as the physical existence of dark matter has not yet been proven.

Three texts (A, B and C) were chosen for the study. One text was extracted from the webpage that ranked highest on Google when the search phrase “what is dark matter?” was entered: a page by the National Aeronautics and Space Administration, NASA (text A). The second text, (Text B) was the article on dark matter from Encyclopaedia Britannica which was chosen as representative of a more traditional encyclopaedia. However, in this case, the online version was used. Finally, text C, consisted of the English language version of Wikipedia (C). All texts were sent in separate files to the expert panel for evaluation.

Text A (NASA’s) does not state the author nor the date when it was written or published. The text contains 1671 words and three images.

Text B (Encyclopaedia Britannica) was published by the online version of Encyclopaedia Britannica. The text is written by Adam Riess and last updated on the 7th of April 2016. The text contains 1230 words and six images/infographics. To access the text, Encyclopaedia Britannica requires the reader to buy a subscription for USD 11.95 per month.

Text C (Wikipedia), is the entry named Dark matter from the English language version of Wikipedia. The text was extracted on the 4th of April 2017. The entry consisted of 6290 words and seven images/infographics on the day when the text was extracted. The article has been edited approximately 5800 times by more than 2500 different users at the time.

The texts were edited to exclude all information on the source. Logos were removed and the fonts were made identical in all three texts. In the case of Wikipedia, references were also removed before the review of the experts. This was done in order to make the texts more alike and to prevent the risk of preconceptions and bias. All images and infographics were kept however, as well as the headings. As might be expected, the articles varied a great deal in length and structure and it might therefore have been possible for the panel to identify the source of each text. However, the integrity of the expert panel was trusted. Each text was changed into a pdf-file which ended with a questionnaire covering all the research questions as well as an open ended request to comment on the texts.

4.2 Dark matter

Dark matter is a physical concept used to explain and describe how spiral galaxies and other cosmic structures are formed and the way in which they gravitate. Apparently they gravitate towards something that cannot be seen, and one hypothesis is that this something is particles referred to as “dark matter”. This hypothetical dark matter seems to outweigh all visible matter by a ratio of five to one, suggesting that our universe cannot be explained by known models. As mentioned above, many physicists are searching for these invisible particles and it is a research topic of interest for many scholars. However, the dark matter hypothesis assumes scientists know how matter in space ought to move in the first place. It can indeed be argued that dark matter does not exist after all. An alternative approach is to reformulate gravity itself. Perhaps it works in a different way than either Isaac Newton or Albert Einstein predicted. Alternative explanations have been published by for example Erik Verlinde (2016). Verlinde suggests that the deviations in gravity can be explained by dark energy rather than particles.

Evidence for dark matter is widely sought for by many experimental and theoretical physicists all over the world. Candidate constituents for this mysterious form of matter, which according to some estimates could make up as much as 90% of all matter in our universe, are pursued at highly sophisticated experiments all around the world, such as LHC at CERN, the large underground Xenon experiment, and the International Space Station.

4.3 Expert panel

The study aimed to investigate and compare the quality of web based sources on scientific information. To do that, ten physicists were contacted and asked to participate. All of them were professors or senior researchers at Chalmers university of Technology in Gothenburg Sweden or Stockholm University, Sweden. Two declined to participate due to lack of expertise in the specific topic and one declined because of lack of time. Thus the panel consisted of seven specialists.

Informant 1 is a PhD and senior researcher in theoretical plasma physics from Chalmers University of Technology with significant pedagogical experience. Currently he is employed as a consultant for a company in space industry and he also teaches courses in a physics master programme at Chalmers.

Informant 2 is a professor at Chalmers University of Technology. He is a theoretical/ mathematical physicist with an extensive experience in elementary particle physics. His current research interest focuses on the analysis and modelling of biological systems, in particular in

neuroscience, using methods from statistical physics. He has previously been head of the department.

Informant 3 is a professor in subatomic and plasma physics at Chalmers University of Technology. He has been mainly involved in research in quantum field theory and string theory with emphasis on their formal aspects. He is also interested in phenomenological applications of quantum field theory and model building. He teaches physics courses ranging from classical mechanics to physics beyond the Standard Model.

Informant 4 is a professor in theoretical physics at Chalmers University of Technology. He specializes in string theory and M-theory and is also head of education for the engineering physics programme.

Informant 5 is a professor at the physics department at Stockholm University. His work focuses mainly on astrophysical searches for particle dark matter, with gamma-ray telescopes on satellites. He also teaches various courses in physics.

Informant 6 is a senior researcher in satellite measurement technology, with a PhD in plasma physics from Chalmers University of Technology. He currently works as a research consultant in the field of GNSS Radio Occultation in collaboration with RUAG Space AB, the Technical University of Blekinge, and Chalmers University of Technology.

Informant 7 is an assistant professor in subatomic and plasma physics at Chalmers University of Technology. His expertise is in theoretical astro particle physics - the interdisciplinary research area lying at the interface of elementary particle physics, nuclear physics, astrophysics and cosmology. He conducts research on dark matter theory and phenomenology with a focus on dark matter direct detection, dark matter astronomy and astrophysics, and dark matter model building.

4.4 Design and data collection

The questionnaire that was used was based on eight variables that were established according to Wikipedia's own quality criteria as well as Wang & Strong's (1996) dimensions of quality (See Section 3). The model for assessment was also inspired by the one used by N. J. Reavley et al. (2011). The content of each article was thus rated on a five point scale in the following areas: accuracy, currency, breadth of coverage, images, structure, neutrality, relevance and readability. The reason that these variables were chosen was that they were applicable to the problem and they were theoretically established.

The scale that was used was a five point Likert Scale, which is an ordinal psychometric measurement of attitudes, beliefs and opinions. Each question had a multiple choice format from 1-5 where 1, 3 and 5 were labelled with guidelines (see example below). This allowed the informants to respond in a degree of agreement. (Holme & Solvang 1993)

Table 2: Variables

Accuracy	Are there errors of fact or unsubstantiated opinions?
Currency	How up to date is the content?
Breadth	How broad is the range of topics?
Images	Do the images illustrate and contribute to understanding?
Structure	To what degree is the text well-structured and coherent?
Readability	Is the text suitable for someone with limited education?
Neutrality	Is the text somewhat biased?
Relevance	Is the content of the article fully relevant?

For each variable, guidelines were specified as to what the different scores represented e.g. for the variable Accuracy, the following guidelines for scores 1, 3 and 5 were used:

1=many errors of fact or unsubstantiated opinions

3=some errors of fact or unsubstantiated opinions

5=all information factually accurate

Each questionnaire also included an open request for the informant to comment on the text. The questionnaires were placed at the end of each text in electronic form. The scores and comments were entered by the reviewer directly in a pdf-file. The panel members received the texts and questionnaires by e-mail. After completion, the questionnaires with the scores and comments were returned and analysed. One of the panel members was also interviewed for more in-depth answers on thoughts on the texts and Wikipedia.

Thus, all articles were assessed on the basis of the same criteria and given a total score as well as a mean value for every variable. The expert panel's comments on the texts were also collected and analysed. The texts were later compared to each other with regards to the criteria and comments.

The questionnaire can be found in appendix A.

4.5 Interview

To complete and deepen the data collection, a semi-structured interview was made with one of the panel members, informant 1 (I1). The interview aimed to further assess the quality, strengths and weaknesses of the texts as well as to further discuss the credibility of the different sources. The interview took place on the 25th of April 2017 in Varberg, Sweden and the language that was used was Swedish as it is the mother tongue of the informant. The interview took place after the informant had read the texts and completed the questionnaire and it took approximately 50 minutes to carry out. A recording was made of the interview and a transcript in Swedish can be found in appendix B.

The interview questionnaire consisted of a number of questions aiming to investigate the following areas:

- The researcher was asked to further elaborate his thoughts and opinions on the three texts
- General reflections on the texts from a researcher's perspective
- Pedagogical qualities of the texts

- General experiences of Wikipedia and its credibility
- Potential for further use of Wikipedia as a mean for spreading research results.
- Potential as a source of reliable information for the general public on complex matters
- General reflections on the use of encyclopaedias

The data from the interview was integrated in the results as well as in the final discussion.

4.6 Ethical considerations and validity of the study

Ethical considerations were not really required. The integrity of the panel members was considered high. Their names remain anonymous throughout this report but their names are mentioned in the acknowledgements.

The validity of this study was considered to be high due to the level of expertise of the panel. The methods used are well-established in the social sciences. Nor did the expert panel mention any inadequacies. However, the external validity is rather low as the results cannot be generalized to other entries on Wikipedia.

4.7 Limitations of the study

This study focused on one topic only and a single Wikipedia article from the English language version. Thus the results cannot be generalised to other topics on Wikipedia.

5. Results

In the next three sections, the scores and the comments will be summarized for each text. After that, the results from the interview will be presented.

5.1 Presentation of results of text A, NASA

Text A was published by NASA. The text did not state the author nor the date when it was written or published. The text contained 1671 words and three images.

Table 3: Text A, NASA *Dark Matter, Dark Energy*

Informant:	1	2	3	4	5	6	7	Total	Mean
Accuracy	3	4	3	3	3	3	4	23	3,29
Currency	3	3	3	3	2	3	3	20	2,86
Breadth	1	2	2	2	4	2	3	17	2,43
Readability	1	2	4	4	2	3	3	19	2,71
Images	1	2	3	2	2	3	3	16	2,29
Structure	4	2	2	2	1	1	4	16	2,29
Neutrality	2	4	5	4	4	2	5	26	3,71
Relevance	1	3	3	3	3	4	5	22	3,14
Total	16	23	25	23	21	21	30	159	
Mean	2,0	2,88	3,13	2,88	2,63	2,63	3,75		2.84

This text was considered quite brief and shallow by the panel which may explain some low scores for breadth and currency. The results show that the accuracy and relevance aspects were generally considered acceptable but with some errors. Structure and images scored relatively low and the estimated readability varied. The text's highest score was for neutrality meaning that bias was not really considered an issue.

The text was more popularly written and less technical than the others but it still contained difficult terminology which may have affected the readability scores.

The panel members pointed out that the text concerns dark energy as much as dark matter. The two concepts are partly related but dark matter could be described better by the study of galaxy dynamics. The account of dark matter was considered brief. Regarding the dark matter part, the text was rated as *“very superficial”* by informant 1. *“Dark matter comes in quite ad-hoc and is somewhat less accurate”* commented informant 5.

Some facts are just stated without explanation which was pointed out by several of the panel members. The text mentions WIMPS and axions without explaining what they are. The text does not address the problems with galaxy dynamics which is a weakness. The author brings up the possibility of challenging Einstein's theory of relativity but with an over-simplification of the mathematical models.

The text is considered correct with no apparent errors detected. However, some of the experts pointed out that the editing was poor and one of the experts was very critical: “*Lots of room for improvement but at least no factual wrong as far as I can tell by a cursory view*” (informant 3). Informant 7 commented that he was missing important arguments in the text. Informant 4 commented that the text was “*sloppy and has a tendency towards mystification*”. One of the figures was also criticized as it was not clear whether it was a diagram or not. The panel also found that the text had a “*disturbing lack of historical account*” (Informant 4).

5.2 Presentation of results of text B, Encyclopaedia Britannica

Text B was published by the online version of Encyclopaedia Britannica. The text was written by Adam Riess and as mentioned above, it was last updated in April 2016. The text contained 1230 words and six images/infographics.

Table 4: Text B, Encyclopaedia Britannica, Adam Riess *Dark Matter*

Informant:	1	2	3	4	5	6	7	Total	Mean
Accuracy	5	3	1	4	3	4	3	23	3,29
Currency	4	3	1	3	5	4	3	23	3,29
Breadth	3	2	2	2	4	1	2	16	2,29
Readability	2	3	3	2	1	2	3	16	2,29
Images	3	2	2	2	2	1	3	15	2,14
Structure	3	2	2	4	3	1	3	18	2,57
Neutrality	3	3	5	3	4	3	5	26	3,71
Relevance	4	3	3	4	4	3	5	26	3,71
Total	27	21	19	24	26	19	27	163	
Mean	3,38	2,63	2,38	3,0	3,25	2,38	3,38		2,91

The results show that this text’s strengths are in its relevance and neutrality with its accuracy and currency also being considered relatively good. The score results and the nature of the comments of this text varied between the panel members. While some found it to be quite correct and up to date, others rated it as low on both accuracy and currency. Some relative consensus could be found regarding the breadth, the quality of images and the relevance.

The text was considered more technical than text A. At the same time, the technical level and quality of the text was not well matched with the illustrations. One of the experts regarded the history description of dark matter as oversimplified (informant 7). The panel found the images as infantile and funny which did not go well with the technical level of the text.

Some errors were found in the text. The stated percentages in the beginning were incorrect. Moreover, baryonic matter was lumped together with dark matter which is misleading and in disagreement with the picture shown. Informant 7 noted that “*Cold dark matter is not necessarily heavy*” and that “*Axions are not WIMPs*”.

One of the experts questions the use of a simplified model for deciding quantities of each type of energy/mass. One of the experts generally rated the text as bad. *“The text is terrible. Just terrible”* (Informant 3). The panel also found the text to be somewhat difficult and demanding to understand as the level of technicality is high. *“The text would be rather confusing for the intended lay readership”* informant 2 commented. The technical level was considered unnecessarily high for a text as brief as this. Even though the text scored relatively well for neutrality, one of the experts pointed out that there was some obvious bias in the text against theories of modified gravity.

One of the panel members, informant 5, held this as the best text out of the three *“The text reflects with good accuracy the current ideas about the nature of dark matter, though [...] on a rather superficial level. This is in contrast with a few rather precise numbers given (which are moving targets and therefore should be turned into coarser statements)”*.

5.3 Presentation of results of text C, Wikipedia

Text C is the entry named Dark matter from the English language version of Wikipedia. The text was extracted on the 23rd of March 2017. This entry consisted of 6290 words and seven images/infographics. The article had been edited approximately 5800 times by more than 2500 different users.

Table 5: Text C, Wikipedia *Dark Matter*

Informant:	1	2	3	4	5	6	7	Total	Mean
Accuracy	5	4	4	5	3	3	5	29	4,14
Currency	4	4	5	4	2	4	4	27	3,86
Breadth	4	4	5	5	4	4	5	31	4,43
Readability	2	1	1	1	1	2	2	10	1,43
Images	4	3	4	4	2	4	3	24	3,43
Structure	4	2	5	4	1	1	4	21	3,0
Neutrality	4	4	5	4	*	2	5	24*	4,0
Relevance	4	4	4	5	4	3	5	29	4,14
Total	31	26	33	32	17*	23	33	195	
Mean	3,88	3,25	4,13	4,0	2,43	2,88	4,13		3,55

*There was a loss of data for this text as Informant 5 did not place a score for neutrality. This was compensated in the calculations of the mean scores.

This text was considered the best out of the three by all panel members but one. The text stands out from the others by earning higher scores on all criteria except readability. The text scores really well on accuracy, breadth and relevance. In addition it has relatively high scores for both currency, images and neutrality. Most variations were found regarding the structure. The text was considered as substantially more comprehensive and contains an in-depth account of dark matter and different theories that can be used to explain it. *“By far the best of*

the three texts” informant 3 concludes. Informant 7 agrees: “*By far the best text among the three texts I have read*”.

The text scored well on most parameters but some problems were noted with the structure and readability. One of the panel members, informant 2, comments that the text is rather long and it would be improved if it was better structured, his suggestion is a “*summarizing introduction and a clearer division into subsections*”.

One of the experts emphasizes that the level of detail and the elaborate explanations brings a great degree of credibility to the text. The text also gets praised for its breadth. “*This is a very broad exposition of the topic, quite technical at some points, but this is needed to get to the level of detail which the text reaches*” (informant 4).

Another advantage that is pointed out with this text is that it mentions the fact that there are different, alternative theories to dark matter to explain movements in spiral galaxies. However, these are not presented in detail.

The major critique of this text concerns its low scores for readability. The reader needs a very high level of prerequisites, namely university studies in physics, to be able to fully understand the text. In addition, informant 7 points out that one of the sections in the beginning of the text is not well integrated in the whole texts.

5.4 Comparison

Table 6: Comparison of scores

	A: NASA		B: EB		C: Wikipedia	
	Score	Mean	Score	Mean	Score	Mean
Accuracy	23	3,29	23	3,29	29	4,14
Currency	20	2,86	23	3,29	27	3,86
Breadth	17	2,43	16	2,29	31	4,43
Readability	19	2,71	16	2,29	10	1,43
Images	16	2,29	15	2,14	24	3,43
Structure	16	2,29	18	2,57	21	3,0
Neutrality	26	3,71	26	3,71	24*	4,0
Relevance	22	3,14	26	3,71	29	4,14
Total	159	2,84	163	2,91	195	3,55

* Loss of data regarding neutrality lowers the total score for text C

Table 6 shows that the total score for Wikipedia was a lot higher than for the second best text, EB (Encyclopaedia Britannica). Wikipedia earned higher scores for all variables except for readability where both NASA and EB were considered better. Wikipedia also scored lower on neutrality but the loss of data disables the comparison.

Table 7: Summary of scores for each informant

	A: NASA	B: EB	C: Wikipedia
	Mean	Mean	Mean
Informant 1	2,0	3,38	3,88
Informant 2	2,88	2,63	3,25
Informant 3	3,13	2,38	4,13
Informant 4	2,88	3,0	4,0
Informant 5	2,63	3,25	2,43
Informant 6	2,63	2,38	2,88
Informant 7	3,75	3,38	4,13

This table shows that Wikipedia was the preferred text for all informants but informant 5, who on the contrary placed it as the least preferred text. The ranked preference for the other texts varies with four informants placing NASA's text as second best and two placing EB (Encyclopaedia Britannica) as second best. Informant 5 prefers text B, giving it much higher scores than the other texts.

It can be noted that none of the texts scored higher than 4.13 by any one panel members and none lower than 2.0. There is some internal variation between the informants with informant 5 and 6 generally rating all texts lower.

5.5 Results from the interview

This section will account for the findings of the interview with informant 1.

5.5.1 Texts A, B and C

The informant was asked to comment further on the texts. Regarding NASA's text, the respondent was sceptical to the text's focus:

For the universe to look like it does today, you must have a certain distribution of dark matter and dark energy according to some percentages. That is basically what that article is based on. But there are other, more important things I think you could focus on. The behaviours of matter should appear differently in the spiral galaxies if gravity worked as it does on earth. I think that's probably the most important reason ... to study dark matter. And it was not mentioned at all. But the article is not so much about dark matter but about dark energy.

Another point that was raised in the interview was the fact that NASA is not a research institute. They are not an encyclopaedia and their foremost mission may not be to inform or educate the general public. According to the interviewed informant, NASA has a strong brand which would probably be associated to high quality also for professional physicists. Both NASA and theoretical physicists want to create legitimacy for cosmology in general. This is also true for academy, especially in cosmology.

Both NASA and other physicists were said to build a mysterious image of space.

Just look at the fact that it is called dark matter ... such a thrilling name... that brings science fiction to mind. It is much better than calling it 'invisible matter' ... Lots of cool names ... String theory, M-theory ... topics that really lack legitimacy. They belong to mathematics and not physics.

Text B was considered as vague but serious by the interviewed informant. The level assumed was regarded as very general. However, it featured some historical accounting that was found interesting. The text explains how the concept of dark matter emerged and what empirical observations led the theory to develop. Compared to text A, more breadth is there. A paragraph at the end dismisses other theories which the informant found to be a weakness. It postulates that gravity according to the theory of general relativity would be the same and true everywhere, on earth and throughout the universe. This is a problem in the view of informant 1.

Text C was considered as contentious. The respondent identified a classic Wikipedia structure and thus decoded the source. The informant states that the text illustrates how complicated the topic is.

This Wikipedia article would allow students to read and get a basic overview of the topic, but to understand dark matter and its impact on cosmological models, one has to understand cosmological models. Then you need ... What do I know? Read Steven Weinberg's book about gravity and cosmology. That contains page after page with equations.

Thus, for deep understanding, Wikipedia is probably not enough, you may have to refer to textbooks.

"You can understand this topic on different levels. But Wikipedia is definitely a good gateway to start".

Moreover, the quality of the article was put in the perspective of its creation.

It is a sort of self-organizing critical reviewing. There seems to be enough highly qualified people with enough ... at least for most articles...adequate people with enough knowledge who contribute to the article so it is good enough".

5.5.2 Pedagogical qualities of the texts

The interview revealed that all texts had an acceptable pedagogical standard for someone who has the right prerequisites. The Wikipedia page was considered to have a good pedagogical logic, where the parts constituted a good entity.

I do not think it was the case in this article, but in general, Wikipedia can sometimes be a bit messy. You notice that there is coherence within each subheading but then there is no common logic linking them. You have to do the linking yourself. But it is usually a very good starting point for gathering information. It is also quite rare for someone to read a Wikipedia article from start to finish but you look for ... the part that interests you and then you read that section.

In this case, the pedagogical features were regarded as logical. But the same cannot be said for Wikipedia in general according to informant 1.

This page [dark matter] was very good and has a good educational logic. There are many other pages that may be correct in terms of content but they have such a bad coherence [...] Perhaps it is easier for a single person to write educational material pedagogically in order for students to understand better.

The images in the Wikipedia article were said to be adding to some pedagogical value.

I think the Wikipedia article, text C, has an interesting image showing the cosmic microwave background radiation mapped up by this W-map experiment or satellite. The interesting thing is that it is not evenly

distributed over the celestial sphere. That image is not included in any other article. The Wikipedia article also has a very good ... a very simple plot of velocity against distance. It illustrates these galaxies. The further out a star is located from the centre of a spiral galaxy, the slower it should be moving. But the observed velocity is much higher than it should be. It is substantial, it's a good picture.

Some pictures that were found in the texts, e.g. a histogram, were considered redundant as they were meant to illustrate very basic proportions where the figure alone would be sufficient.

5.5.3 General reflections on encyclopaedias

The interview showed that Wikipedia is not necessarily seen as an encyclopaedia by its users. When asked about his views on encyclopaedias, the respondent said that he does not use them “*definitely not in my research anyway*” but he stated that when he needed to verify information he turns to internet and Wikipedia: “

First, I google and then I check the Wikipedia page. Sometimes I need to consult special articles and if so, I have to download them from certain servers that I subscribe to.

The informant associated the concept of encyclopaedias with textbooks and remembered using them in his childhood. He was not very familiar with Encyclopaedia Britannica: “*I do not know anything [about Encyclopaedia Britannica]. I have heard of it but never used it*”.

5.5.4 Credibility

When asked about the perceived credibility of Wikipedia, the respondent regarded it as high.

In my experience, Wikipedia is correct in general. I believe this is a widespread opinion, at least in my field. Wikipedia is always used. [...] You have to scan the text to see if it seems ok. That it is up to standard so to speak. There are examples of texts with errors, but with time, you train yourself to see if the information is correct or not. If it is not, you have to look further. But that does not happen often these days, the entries are often very good.

The informant considered NASA as a reliable source as well. He emphasized that NASA's trademark comes with a reliable connotation.

So you use the source that you find adequate. In this case, the text from Wikipedia was much better. But generally ... The trademark of NASA comes with a certain weight. It feels like you should be able to rely on it. Now, NASA is not a research institute but one expects them to convey knowledge of space correctly. I think many people have the feeling that you can trust NASA blindly, I kind of do to...

The informant was asked who he thought may have written the Wikipedia article on dark matter. Would it be amateurs or academics?

I think it is mostly theoretical physicists ... academics mostly. Perhaps students to some extent. But mostly academics at any level who are dedicated to the classic idea of dark matter. But then there is a section on alternative theories ... but I do not think there is any doubt that it is a set mainstream physicists who wrote the majority of the text.

5.5.5 Communication with society

The informant was asked whether he would ever consider contributing to Wikipedia himself. His reply was that he had not thought about it. In his case, his research is so specialized he would find it difficult to fit into any existing Wikipedia article. When asked what he would do

if he found an error while reading, the informant stated that correcting a page had not yet crossed his mind.

Now that you mention it... the thought to create an account for myself and correct or edit something never crossed my mind. I would just conclude that there was an error and move on. But usually there are no errors, usually Wikipedia is very good.

In conclusion, informant 1 states that Wikipedia is reliable, often correct and well used within the scholastic community.

6. Discussion

This section aims to analyse the findings and to discuss them in relation to the theoretical background.

6.1 Wikipedia versus NASA and Encyclopaedia Britannica

The results show that the texts are considered to be very different. Both the length of the texts, the focus of the content and the quality differ. *“It is like comparing apples and oranges”* one of the experts concluded. Another informant stated that *“The short answer is that two are terrible (NASA and EB) and one is good (Wikipedia)”*.

The study showed that there was a strong preference for Wikipedia’s article on dark matter among almost all the panel members. The text scored high on most parameters and there was a good degree of consensus. No specific errors were pointed out, no vandalism was detected and the text seemed up to date. The great scope and breadth of the article add to the perceived quality. The fact that the article is very long and elaborate could possibly bring in a higher risk for mistakes but according to the ratings, the quality is solid throughout the text. The number of edits and contributors would also be potentially make the text more shattered or contradictory. The findings here suggest that this is not true for the dark matter entry. The overall judgment could therefore be interpreted as a recommendation to turn to Wikipedia.

Even though the findings show that Wikipedia keeps a higher standard than the compared sources in most aspects, it still consistently scored low on the readability parameter. Wikipedia is thus considered as advanced and demanding – perhaps too advanced for the intended amateur readership. This leads to the question who the intended reader is? For the average member of the public, Wikipedia may not give the explanatory information one was seeking.

NASA’s text probably never intended to serve as an encyclopaedia but perhaps to generate interest for space -related matters and provide information about the agency’s activities. The reason why it was compared at all was that it ranked highest on Google and that it could be assumed that NASA’s credibility is high, given that they are an authority. NASA’s text was regarded as reasonably correct and up to date, even though it remains unknown how old it is. Its pedagogical qualities seemed poor though as the text was criticized for being both oversimplifying and for using too advanced terminology at the same time. The general score was relatively low for NASA’s text. The interview revealed that NASA is considered a reliable source in general but in this case, the text was not of a high standard and a great deal of criticism was addressed towards it.

The purpose and intended reader for NASA’s text is not obvious. However one can observe that the NASA text uses a different rhetorical style from the other two texts. In the interview, informant 1 pointed out that on the surface, NASA may seem to be devoted to space travel, satellites, fancy images of stars and telescopes, but in reality they are strongly linked to research in theoretical physics. The financial aspect of NASA was also mentioned. *“There is a billion industry involved in experimental physics, the purpose of which is to answer questions in elementary particle physics. Then they found the Higgs particle ...”* In spite of this, NASA’s text scored highest on neutrality out of the three texts.

Encyclopaedia Britannica's text does not score very well. It is also clear that it divides the expert panel's opinions more than the other texts. The reason for this is unclear but some of the informants seem to find errors while some still give it high scores for accuracy. Apparently, the accuracy of the text can be debated. However, there are figures that are not consistent with the corresponding figures in the compared articles. In summary, it does not score very well. Given that the text is from a centrally controlled encyclopaedia, with a trustworthy brand which also charges the reader to access the text, one would not expect simple errors like that.

In other words, neither the strong brands of NASA and Encyclopaedia Britannica, nor the fact that the source is controlled by experts serve as a guarantee that the text is correct and of a high quality. In Encyclopaedia Britannica's case, you have to pay for a subscription to reach the full article on dark matter. That probably gives the reader the impression that the quality of the information is high since you have to pay for it.

The interview revealed that the concept of dark matter should perhaps be described more humbly. It was suggested that it should be viewed more as a hypothesis than a given fact. The portrayal of the phenomenon depends to a great extent on the vantage points that are chosen. This affects the figures and models that are presented and that can bring debate to what should be considered as accurate. The particular perspective chosen may also bring in bias as all conceivable explanations are not given equal weight in the discussion. All texts favour the hypothesis that there is indeed dark matter and only two of them mention alternative theories briefly. The perceived accuracy of the articles could be influenced by the informants' own sympathies but also by how the texts are distributed.

It could be noted that one of the informants, informant 5, deviated somewhat from the others. This informant is from a different institution than the rest of the panel. Given that the informant could identify the sources of the texts, this could possibly suggest that the status of Wikipedia may vary between different research institutes. However, a lot more data would be needed to investigate this. This deviation could of course have many other explanations as well.

One question that remains is who the intended target groups of the texts are. None of them would be suitable for a person with no prerequisites. From that perspective, the level of satisfaction with the texts could be very low depending on the reader.

6.2 The results in relation to previous research and theories

When applying Wikipedia's own quality metrics, the entry on dark matter can be said to qualify as high quality in most of the defined criteria. The accuracy, appropriateness of images, exclusion of false information, comprehensiveness, referencing and neutrality are all impressive. The only questionable parameter is the appropriateness of style. It is not clear who the intended reader is but the entry on dark matter is more appropriate for trained scholars than the interested public.

Wikipedia scores higher than the other sources on the currency variable which means that in this case, Wikipedia seems to indeed be better updated which is suggested by their own description of their quality (2017).

The results show that the Wikipedia entry also can be considered as associated with high information quality according to Wang and Strong's (1996) categories. The intrinsic infor-

mation quality and the contextual information quality are regarded as high. However the representational information quality, i.e. interpretability, ease of understanding and conciseness are not Wikipedia's strengths in this case. Regarding accessibility information quality, this category deals with security of information and how easy it is to access, was not investigated in this study.

Wikipedia can also be said to fulfil Alexander & Tate's (1999) requirements for good information in this case. The results showed that the entry on dark matter was considered both objective and complete. Pluralism, which is their third dimension, is a core feature of Wikipedia.

Floridi (2013) pointed out that satisfaction with the information is an important measure of information quality. Wikipedia turned out to have a high user satisfaction among the expert panel in this case but this does not necessarily apply to the general public.

The data showed that Wikipedia can be considered as credible as some of the researchers commented that they themselves oftentimes turn to Wikipedia for research purposes. Rieh & Danielson (2007) connect the main aspect of credibility to the sender/author of the information. The anonymity of Wikipedia could be expected to lower its credibility but in this case it seems that my data contradicts this. The texts by NASA and Encyclopaedia Britannica could in this context be regarded as more credible with regards to the legitimacy of the authors but the fact that they score lower on accuracy and currency should raise the question whether this is a valid point in this case.

The results of this assessment are in line with some of the studies that were previously made where Wikipedia also was found to hold a higher quality than the compared sources. Similarly to Reavley & Jorm's (2001) study on mental illness information online, readability was the weakness in this case as well. Unlike Hasty's et al. (2014) study on costly medical conditions, no errors were pointed out in the entry on dark matter. However, it did not get full scores for accuracy by all panel members so there may be imperfections in the text.

Regarding the potential for bias, in this case, there are different explanations for dark matter to lean towards. Some researcher sympathize with the dark matter theory and some with modified gravitation theory. Some obvious bias was detected in the text by Encyclopaedia Britannica but no problematic bias was pointed out in Wikipedia's text where several theories were accounted for.

Vandalism could not be found in this Wikipedia entry. It may be hard to think up a reason why anyone would want to vandalise an article on dark matter, but the same could probably be said for many topics that have indeed been festered with disinformation.

6.3 Credibility of the sources

The data suggest that Wikipedia nowadays has a very high level of credibility among physicists. Informant 1 stated that *"I can safely say that most physicists that I know and work with use Wikipedia on a regular basis for reference and for fact checking"* One of the experts that declined to participate in the study also mentioned by e-mail that he usually refers to Wikipedia in his own research in mathematical modelling. A certain caution has to be taken, he said, but in general, Wikipedia is considered as a reliable source.

The interview also revealed that NASA would be considered an equally reliable source, at least by informant 1. NASA would be expected to provide a guarantee for correct and updated

information since they are the world-leading authority on space related matters. The data also showed that NASA's text was considered the most neutral out of the three which strengthens their credibility.

None of the experts commented on the credibility of Encyclopaedia Britannica per se. Informant 1 implied that it is probably not very well used or known in Sweden. However, the fact that it is a well renowned encyclopaedia, supposedly edited by specialists supports the credibility to the source. Moreover, the information was not for free but a paid subscription was required to access the article. This may also give the impression that the information is of a high quality and from a reliable source.

6.4 Strengths and weaknesses

The main strength of this study is the kind participation and strong commitment to their task of the highly qualified expert panel. The fact that the specialists that were asked to assess the texts were eager to do so increases the validity of the study. The fact that their assessments were relatively alike also suggests that the results are reliable and not due to the personal factor.

Methodologically, the questionnaire and interview techniques involving an expert panel that were used have been widely tested in many earlier studies before with interesting results which indicates it is valid and reliable. However it needs to be kept in mind that the use of the expert panel can also be seen as a potential weakness. There could be prejudice or prospective bias affecting the answers. A lot of trust is put in the experts' integrity. Sometimes the experts' views may be contradictory. Moreover, in the present case the work was not completely blinded. It was probably easy for the informants to guess the sources of the texts. There may be preconceptions affecting the panels' judgments. Even though the expert panel were highly qualified, there is a potential for possible errors or differences in their background that may affect their assessments.

All the panel members were European males which also may affect the results. All but one are from the same institution which means they are possibly influenced by each other's work, scientific culture and traditions.

7. Conclusion

The Wikipedia community and website represent a remarkable experiment in collective intelligence, and have taken the ideals of this notion further into practice than any other reference material on the Internet. In line with the ideal of collective intelligence, it should be possible to aggregate disparate ideas into a cohesive and presentable whole - but this would surely be difficult to accomplish even if all such ideas were uncontroversial, objective, and verifiable. Against this background this study has sought to examine the output of collective intelligence in a context where knowledge is contested.

The results show that in the case of dark matter, the English version of the Wikipedia entry on dark matter is of a very high quality on all the measured parameters except for readability. When it comes to the case of dark matter, one can safely turn to Wikipedia for reference. However, the prerequisites needed to understand the article involve a prior knowledge of physics. Those who are in search for a simpler explanation of the concept of dark matter may have to look further still. Even though the text from Wikipedia is not formally peer reviewed or written by experts, the scientific standard is still high. The contributors perform a kind of reviewing process among themselves which with the effect of increasing the quality.

The results also indicate that Wikipedia is of a higher quality than the centrally controlled sources with which it was compared. These scored lower on all the parameters except for readability. Though the readability of the other texts was not rated highly either. Even if the results can't be generalized, there is thus a strong reason to believe that Wikipedia has achieved high credibility.

For researchers, there are plenty of incentives to use Wikipedia as a communication platform to further spread research outcomes. The frequent usage by both scholars and the general public and its high level of accessibility through search engine algorithms, in combination with the often perceived high quality and credibility of the articles should be convincing arguments for anyone to become a 'wikipedian'. However, as shown by the present work, efforts to increase readability and to improve structure should be encouraged.

7.1 Key take-aways

In summary, my most important findings are as follows:

- The entry on dark matter on Wikipedia's English language version has an excellent scientific quality with regards to accuracy, currency, breadth, neutrality and relevance
- Compared to sources written by authorized experts, in this case NASA and Encyclopaedia Britannica, Wikipedia gives a broader, more correct, more detailed and more relevant account of the topic of dark matter
- The fact that Wikipedia is not connected to academia or acclaimed professionals does not seem to impair the quality and neither does the fact that it has a great amount of contributors and edits

- Wikipedia seems to have gained a high credibility in the research community, at least among physicists
- Both NASA's and Encyclopaedia Britannica's articles on dark matter had a lower degree of quality than expected considering their brands' high level of credibility

7.2 Contributions

The practical contribution of this study is to further emphasize that Wikipedia repeatedly shows a high level of quality and credibility among science scholars. It also shows that there are strong incentives not only to use and refer to Wikipedia but also contribute to its content. In Sweden at least, communication of research outcomes to the broader community is increasingly regarded as a prerequisite for receiving research funding from research councils. Wikipedia could be a viable way to contribute and spread knowledge and thus create a dynamic interaction between academia and members of the public without vulgarising the research.

This study demonstrates that there is some empirical evidence for the high quality of Wikipedia. The findings suggest that it can be safely used and referred to and that it has a higher credibility than what is popularly believed.

The results suggest that in comparison to authorized expert knowledge, Wikipedia is able to produce better content as articles are continuously and substantially revised. This is consistent with a best-case scenario where contributors with different perspectives engage in digital communication with each other. In that light, I think this is an important finding.

Finally, the findings imply that Wikipedia could be used for pedagogical purposes. Perhaps even in teaching. Advantages in relation to textbooks is that Wikipedia can be, and often is, quickly revised. However, it is of great importance in that case that the information is accurate and neutral.

7.3 Suggestions for future research

It would be interesting to investigate different language versions of Wikipedia and perhaps distinguish different scientific traditions. It would also be interesting to examine articles on more controversial subjects. The perceived usability of the texts would be interesting to measure as well. Perhaps it would be just as interesting to ask non-scientists how they rate Wikipedia's sometimes very complicated accounts for different subjects.

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Appendices

Appendix A Questionnaire:

Please rate the text according to the stated criteria:

Accuracy; how correct is the text in your opinion?

1=many errors of fact or unsubstantiated opinions

3=some errors of fact or unsubstantiated opinions

5=all information is factually accurate

Score: 1 2 3 4 5

Currency; how up to date is the text in your opinion?

1=generally not up-to-date

3=information partly up-to-date

5=all information completely up-to-date

Score: 1 2 3 4 5

Breadth of coverage; how well is the topic covered in the text in your opinion?

1=limited or unsatisfactory coverage of topics

3=several topics covered

5=a broad range of topics covered

Score: 1 2 3 4 5

Readability: what prerequisites are needed in your opinion to understand the text?

1=readability suitable for someone with university education

3=readability suitable for someone who has completed secondary education

5=readability suitable for someone with some secondary education

Score: 1 2 3 4 5

Images including infographics:

1= several images are misleading or hard to understand

3=the images are partly contributing to the understanding of the text

5= the images illustrate the texts well and contribute to understanding

Score: 1 2 3 4 5

Structure:

- 1= the text lacks structure and coherence
- 3= the structure of the text is acceptable
- 5= the text is very well structured and coherent

Score: 1 2 3 4 5

Neutrality: to what extent is the text neutrally written in your opinion?

- 1= the article is heavily biased
- 3= the article is somewhat biased
- 5= the article is considered fully neutral

Score: 1 2 3 4 5

Relevance: to what extent are the contents of the text relevant in your opinion?

- 1= the article contains a lot of irrelevant information
- 3= parts of the article are somewhat irrelevant
- 5= all parts of the article are considered fully relevant

Score: 1 2 3 4 5

What comments do you have on the text?

Appendix B: Interview

LA Vad är din allmänna uppfattning om uppslagsverk och encyklopedier?

II: Uppslagsverk... Menar du till exempel Nationalencyklopedin då?

LA: ja till exempel.

II: Jag tänker väl främst på Bra böckers lexikon som jag läste en del i som barn men jag kan inte säga att jag använder uppslagsverk idag. Definitivt inte i min forskning i alla fall.

LA: Vad använder du för källor när du vill verifiera information i din forskning?

II: Internet. Först och främst så googlar jag och sen kollar jag wikipediasidan. Ibland behöver jag vända mig till specifika artiklar och då kan det hända att jag får ladda ner den från speciella servrar som man får prenumerera på.

LA: Du nämnde Wikipedia direkt. Kan du beskriva hur du uppfattar Wikipedias trovärdighet?

II: Min uppfattning är att det som står på Wikipedia generellt är korrekt. Jag tror att detta är en spridd uppfattning, i alla fall inom mitt forskningsfält. Där använder man ju alltid det. Sen får man ju använda... Man får göra en liten scanning först och kolla igenom den så att den verkar ok. Så att den håller måttet så att säga. Det finns ju exempel på att det står fel men med tiden tränar man upp sig och lär sig se om informationen är bra eller dålig. Är den dålig så får man söka sig vidare... Men det är inte så ofta nu för tiden, oftast är de väldigt bra.

LA: Hur står sig Wikipedia i förhållande till standardverk och tryckta läroböcker?

II: Det beror på... om det är ett mer... Om man ska kolla upp grundläggande information. Men oftast är innehållet saxat från nån lärobok ändå. Eller i alla fall starkt influerat av någon lärobok. Men det fungerar bra att kolla Wikipedia först och sen om man vill ha mer detaljer kan man kolla någon lärobok. Eller flera läroböcker. För att få ett bra... ett bra ingångsvärde.

LA: Vad kan göra dig osäker på Wikipedias information?

II: Alltså ibland blir man tveksam... när det gäller fysik och matte, om man inte fattar. Och då går man ju vidare till fler källor. Det skulle man ju gjort även om det var en textbok. Så sätter man sig och får räkna själv.

LA: Skulle du kunna tänka dig att själv bidra till Wikipedia?

II: Ja. Eh, jag har nog aldrig tänkt på det. Ja men kanske i och för sig... Det känns nästan som ett... Jag har aldrig funderat på att editera själv. Ja just det... jag tror inte att min forskning... Den är ganska specialiserad. Den har definitivt ingen plats på den generella plasmasidan. Jag skulle nog kunna göra nån sorts artikel av det hela.

LA: Om du hittade ett fel på den generella plasmasidan, hur skulle du agera?

II: Nu när du säger det... tanken har inte slagit mig att själv skapa ett konto och korrigera. Jag skulle bara konstatera att det fanns ett fel. Men oftast är det inte så, oftast är det väldigt bra på Wikipedia.

LA: Vad vet du om Encyclopedia Britannica?

II: Jag vet ingenting. Jag har hört talas om den men aldrig använt den.

LA: Hur ser du på att använda NASA som källa?

II: Alltså man använder ju den källa som är bra. I det här fallet var ju texten från Wikipedia mycket bättre. Men generellt så... Stämpeln NASA kommer ju med en viss tyngd. Det känns ju som man borde kunna lita på den. Nu är väl det i och för sig... NASA är ju inget forskningsinstitut. Men man förväntar ju sig att de ska förmedla kunskaper om rymden på ett korrekt sätt. Jag tror att många har uppfattningen att man kan lita blint på NASA, det har väl jag lite också...

LA: Hur ser du på NASAs agenda och uppdrag när det gäller att kommunicera med allmänheten?

II: Aha... Ja... så skulle man ju möjligtvis kunna se det... De är ju med och skjuter upp den nya ersätaren till Hubble-teleskopet nu. Och det ska ju utvärdera en del saker som har med mörk materia att göra. Sen är väl NASAs ambition framförallt att lyckas med sina missioner ute i rymden snarare än att utbilda allmänheten. Men det är nog den allmänna uppfattningen att en text som är publicerad av NASA borde vara korrekt.

LA: Text A var skriven av NASA, har du några kommentarer om den?

II: Ja den handlade ju i hög grad om mörk energi. Sen kom den in på mörk materia på slutet. Det som sades om mörk materia var ju egentligen... ganska innehållsfattigt. Begreppen hör väl visserligen ihop men jag tycker man kan... man ska diskutera dem var för sig.

LA: du kommenterade tidigare att texten var ytlig.

II: Ja, den nämner ju axioner och WIMPs och dylikt utan att alls gå in på vad det är. Jag tycker... Det finns en handfull olika anledningar till att forskningsvärlden vill införa teorier om mörk materia. Denna artikeln verkar stötta det... Framförallt tog den upp en grej... För att universum ska se ut som den gör idag så måste man ha en viss fördelning av mörk materia och energi enligt några procentsatser liksom. Det var i princip det artikeln bygger på. Men det finns andra, viktigare saker jag tycker man kunde fokuserat på. Den materia som syns, den ljusa materia den borde bete sig annorlunda i galaxerna om gravitationen fungerade som den gör här. Det tycker jag nog är det viktigaste skälet... att studera mörk materia. Och det nämndes inte alls. Men artikeln handlar inte så mycket om mörk materia utan mörk energi ändå.

LA: en av kommentarerna på texten var att den mystifierar begreppet...

II: Definitivt. Både NASA och andra fysiker bygger upp en mystisk bild av rymden. Bara det att det kallas för mörk materia... Massa häftiga namn... Det för ju tankarna till science fiction. Det är mycket häftigare än att kalla det "icke synlig materia". Både NASA och teoretiska fysiker vill ju skapa legitimitet för kosmologi generellt. Det förekommer inom akademien med. Särskilt inom kosmologin. Fullt med häftiga namn... Strängteori, M-teori... ämnen som egentligen saknar legitimitet. Som är matematik men inte fysik. Man kan kanske uppfatta att NASA har en annan retorik rent ytligt med rymdfärder och fotografier av rymdfenomen men samtidigt är det ju starkt kopplat till teoretisk fysik. Sen har de ju andra missioner, åka till månen och åka till Mars... det är ju mycket mer ingenjörsmässigt. Det finns ju en miljardbransch som sysslar med experimentell fysik där syftet egentligen är att besvara frågor inom elementarpartikelfysik. Sen man hittade higgspartikel... [beskrivning av supersymmetri]

LA: Text B kommer från Encyclopedia Britannica. Vad kan du säga om den?

II: Den här artikeln anger ju andra procentsatser än text A. Någon av dem har ju fel. Kanske har ingen av dem rätt. Jag har inte specialistkunskapen att kunna svara på det på rak arm. Jag tyckte annars att den var ganska vag i allt den sa men det var inte några direkta fel i den. Nivån som antogs var så generell så det sas inte så mycket i den heller. Det finns vissa procentsatser angivna här som jag inte kan uttala mig om som sagt men jag skulle nog lita på innehållet i stora drag. Tonen är seriös. Sen är den för vag för att ha någon användbarhet för mig. Mm.. (paus). Men efter att ha läst alla tre artiklarna så är det ingen tvekan om att jag återgått till text C om jag velat använda texten. Den... den har ju inget mervärde i förhållande till text 3... text C. verkligen inte. Sen kan man kanske ifrågasätta detaljerna häri... men jag tycker ändå den är hyfsat... För det första så handlar den verkligen om mörk materia vilket gör att den kan ta upp lite fler saker. Den förklarar hur den uppkommit... Och vilka observationer som lett till att man... tänker i de banorna. Så en viss bredd finns där. Men det var ett stycke på slutet som... ja... definitivt... den tar avstånd från teorier om modifierad gravitation. Det handlar om att man tänker sig att gravitationsteorin skulle vara lika dan och gälla överallt, på jorden och i hela universum. Det är det som är teorin om mörk materia. Att det finns saker som inte beter sig som de borde enligt... Att det som man ser finns där, då måste det finnas något mer som man inte ser där. Det är då mörk materia. Den andra idén som jag kanske är lite mer anhängare av... eller som jag inte tycker man borde avfärda på rak arm är idén att gravitation kanske inte beter sig likadant i hela universum. Den kanske är annorlunda längre bort. Den kanske beter sig annorlunda när det gäller stora avstånd som galaxer. Det är då något som brukar kallas modifierad gravitation eller ja, MOND. Och den här artikeln... Text B, den tar avstånd genom att säga att det inte finns någon förklaring på hur... till varför gravitationen skulle vara modifierad. Men faktum är att de senaste åren. 10, kanske 15 åren har det kommit upp ett antal teorier som... ja, där man visar på hur gravitationsteorier skulle kunna fungera och varför. Med avstamp i teoretisk fysik... och där man kan förklara gravitationen som... som ett fenomen som beror på andra... vad ska man säga... mer basala saker. Och det skulle då kunna ge upphov till en modifierad gravitationskraft över långa avstånd eller små accelerationer eller nåt i den stilen. Men det kan ju hända att författaren inte riktigt har koll på det som har hänt det senaste...

[förklaring på universums expansion, hur man arbetar med förenklade matematiska modeller] MOND är definitivt en teori som skulle kunna lösa problemet med galaxernas spiralarmar... och hur de ser ut.

LA: Den sista texten, C den är från Wikipedia. Den är skriven av 2500 olika personer med mer än 6000 edits

II: jaha det är så många...inblandade

LA: Eh, det verkar vara stor konsensus att den håller hög kvalitet?

I1: ja den är innehållsrik! Den har ju en klassisk Wikipediastruktur... Den har man ju lärt sig att avkoda. Det här med mörk materia är ju ganska komplicerat. Så om man vill förstå mer än bara lite av det ytliga så behöver man ju kunna lite matte.

(paus)

LA: Vem tror du det är som skriver?

I1: jag tror att det framförallt är teoretiska fysiker... som... akademiker mestadels. Kanske studenter i viss mån. Men mestadels akademiker på nån nivå. Såna som hänger sig den klassiska mörk materia-iden. Men sen är det tillagt ett avsnitt om alternativa teorier... men jag tror inte det råder nån tvekan om att det är en uppsättning mittfårefysiker som skrivit större delen av texten. Jag tycker ändå den.. Alltså tyngdpunkten ligger ju på det här.. på mörk... eftersom det här är en artikel om mörk materia så handlar den ju om mörk materia det är ju inte så konstigt. Alternativa.. och MOND har ju egna artiklar. Det är precis som det ska vara[...] Alltså för att förstå det här... Den här wikipediaartikeln kan en student läsa och få med sig mycket av men för att förstå mörk materia och dess inverkan på kosmologiska modeller så måste man ju förstå kosmologiska modeller. Då behöver man... Vad vet jag, läsa Steven Weinbergs bok om gravitation och kosmologi. Där är sida upp och sida ner med ekvationer. Man kan ju förstå det här på olika plan liksom. Men Wikipedia är definitivt en bra inkörsport. Jag tyckte Text B hade en intressant historisk del som visserligen bara var några paragrafer lång men ändå. Det var väl behållningen med den.

LA: På vilket sätt kan Wikipedia ha en potential för tredje uppgiften? Ja det kan det definitivt ha men då tror jag fler forskare skulle behöva... eller börja använda det... att bli editörer. Jag tror att många tänker på det som ett färdigt verk. Man hämtar information där men man publicerar inte information där. Så har jag sett på det i varje fall.

LA: Vad är det som gör att Wikipedia fungerar så pass bra, alltså att texterna är stringenta och korrekta?

I1: Jag vet inte men jag antar att dels så är det väl någon äger varje artikel, har lite huvudansvar. Jag har ju läst de där diskussionerna på metasidorna, det finns ju en sida om varje artikel... som liksom... där folk som skriver i artikeln kommenterar. Där är betydligt mycket mer rörigt och splittrat än generellt sett vad artiklarna brukar vara.

LA: Vad jag vill komma till... Är det inte konstigt att artiklarna inte är mer röriga än vad de är?

I1: Mm ... Det är en sorts självorganiserande kritikalism. Det verkar ändå vara tillräckligt många med tillräckligt hög... i alla fall vad det gäller de flesta artiklarna. Tillräckligt många med tillräckligt bra kunskap. Som skriver där för att det ska bli tillräckligt bra. Just den här sidan var väldigt bra och har en bra pedagogisk logik. Det finns många andra sidor som kanske innehållsmässigt är korrekta men som har ett så pass dåligt upplägg att det... ja... läser man en lärobok som är skriven av en expert på ämnet, i alla fall de basala delarna av ämnet... Kanske det är lättare för en person att lägga upp det pedagogiskt för att studenterna ska förstå bättre. Jag tycker inte det var så i den här artikeln men generellt sett på Wikipedia kan det ibland bli lite rörigt. Man märker att varje röd tråd följs inom varje underrubrik men sen så finns det liksom ingen gemensam röd tråd som kopplar dem. Den kopplingen får man göra lite själv. Men det är oftast en väldigt bra startpunkt för inhämtandet av information. Sen så är det väl också ganska sällan som man läser en wikipediaartikel från början till slut utan man letar upp det... den delen som är intressant och så läser man den.

LA: har du några reflektioner om bildsättningen?

I1: Bilderna är liksom lite... Jag vet inte ... de är lite handmålade och så. Men jag gillar det... det är ju en smaksak. Jag har inga större åsikter om bilderna. Det är lite histogram och så... eller materiaiinne-håll...

LA: På vilket sätt bidrar bilderna till förståelse?

I1: Alltså när man läser om kosmologi är det alltid kul att se lite kosmologiska observationer, lite bilder och så liksom... i olika spektrum... av galaxer och andra fenomen och sånt där. Så det är ju bra med såna grejer. Sen histogram, när man liksom visar hur stor del av en cirkel 23% utgör, det tycker inte jag... den siffran räcker för mig. Ehm, jag tycker wikipediaartikeln, text C har med en intressant bild som visar den kosmiska mikrovågsbakgrundsstrålningen som mappats upp av den här Wmap-experimentet eller satelliten. Det intressanta där är att den inte är helt jämt fördelad över himlavalvet. Den bilden är inte med i någon annan artikel. Wikipediaartikeln har också med en väldigt bra... en väldigt enkel plot av hastighet mot avstånd. Alltså det handlar om de här galaxarmarna. Ju längre ut en

stjärna ligger från centrum i en spiralgalax, ju lägre hastighet borde den åka med. Men den observerade hastigheten är mycket högre än den borde. Den är talande liksom, det är en bra bild.