Molecular gastronomy in science and cross-curricular education – The case of "Kitchen stories"

Erik Fooladi
Volda University College & Norwegian Centre for Science Education, Norway • ef@hivolda.no

Abstract The recent years have seen an increased interest in science education aimed towards the nature of science and inquiry. Within this context, promotion of reasoning and argumentation in school science has come forth as an important field of research. The present contribution describes the project "Kitchen stories" which seeks to develop a framework for teaching argumentation and inquiry in a cross-curricular setting comprising science and home economics. The explicit teaching of Toulmin's argumentation pattern is utilised for students to analyse claims, expand them to build complete arguments and plan open-ended inquiry with regards to specifications (i.e. claims) about food and cooking collected from authentic sources in everyday life, herein termed "culinary precisions". This way a holistic teaching framework has been constructed incorporating project work, argumentation, inquiry, second-hand investigations, sourcing skills and declarative knowledge. Preliminary results from the study involving pre-service teacher students in science and home economics are described. Possibilities, challenges and prospects are discussed when using kitchen stories for teaching argumentation, inquiry and other pertinent topics in science education.

1. Background

1.1. Argumentation, inquiry and socio-scientific issues in science education

Within the international science education community and among policy makers it has been defined as a major challenge the development of quality teaching methods to promote scientific literacy, focussing not only on *what* we know but also on *how* we know and *why* we do so (e.g. Driver, Newton, & Osborne, 2000; Osborne & Millar, 1998; Rocard et al., 2007). Consequently, the recent years have seen an increasing amount of research and educational material/resources focussing on promotion of various cognitive skills in science education such as talking, reading and writing science (e.g. Fang, Abell, Lamme, & Pringle, 2010; Wellington & Osborne, 2001) as well as the development of students' competencies in reasoning and argumentation (e.g. Driver et al., 2000; Duschl & Osborne, 2002; Erduran & Jiménez-Aleixandre, 2008; Osborne, Erduran, & Simon, 2004). It has been advanced that teachers' own argumentation competency and skills are a prerequisite for quality argumentation to be appropriated in classroom discourse (Osborne et al., 2004). Simon, Erduran, and Osborne (2006, p. 256) contend that within continuing professional development to stimulate teachers to promote argumentation in classrooms "[...] it is teachers' initial understanding of argumentation that determines their development [...]". If we expect these to carry out quality instruction a diverse range of strategies and tools is desirable not only directed towards pupils, but also for the development of pre-service and in-service teachers' knowledge and skills in argumentation.

Science content knowledge, argumentation and inquiry do not exist in a vacuum but are inherent parts of society. Thus, science teaching that takes into consideration science as a societal phenomenon has been promoted for achieving an education that can be experienced as relevant to pupils' own lives (e.g. Sadler, 2009 for a recent review). Consequently we need some rationalisation for how science relates to society, and one possible model was recently described by Roberts and Gott (2010) as illustrated in Figure 1. The model consists of three segments: design and conduct of experiments to produce evidence (left, practical work and science content knowledge); argumentation to generate a claim based on this evidence (middle); the claim as a factor in a socio-scientific issue (far right).

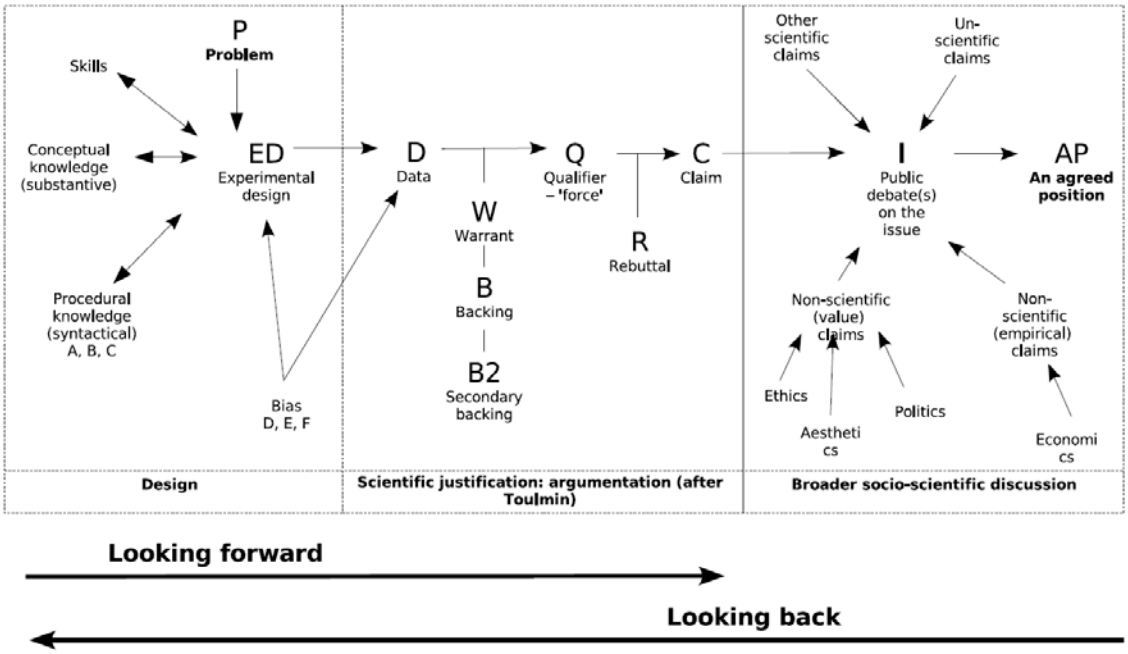

Figure 1. Model for practical work, content knowledge, argumentation and science in a societal context according to Roberts and Gott (2010). Illustration used with permission.

According to the same authors, one might envisage that a researcher would mainly work from left to right in this model "looking forwards" whereas the perspective of a scientifically literate person/citizen would be to work oneself from right to left ("looking back") in order to retrace the evidence for a given claim related to a societal issue. In the work described herein, this model is employed to demonstrate that starting from claims/specifications about cooking ("culinary precisions", see below), one may deal with all these three aspects of science in society in a context which is close to pupils' and students' everyday lives (on the matter of context in science education, see e.g. Gilbert, Bulte, & Pilot, 2011). Herein, this context is given through relevant content from home economics, namely claims and specifications about cooking. Home economics can be seen to draw its knowledge, procedures and ways of thinking from two different spheres: on the one hand natural sciences (e.g. food science, health and nutrition) and on the other hand the practical craftsmanship of cooking which is characterised by experiential knowledge communicated orally or through written recipes. As a result, and as shall be demonstrated below, home economics may offer fruitful contexts for teaching science in a cross-curricular setting, not only concerning declarative knowledge but also scientific methods and ways of thinking.

1.2. Toulmin's argumentation pattern (TAP) and science education

In research related to argumentation, Toulmin's argumentation pattern (hereafter "TAP") (Toulmin, 2003) has gained foothold as an analytical tool for the education researcher in the study of argumentative student discourse (e.g. Erduran et al., 2004; Jimenez-Aleixandre, Rodriguez, & Duschl, 2000; Zohar & Nemet, 2002). In some cases TAP has also been used in the explicit teaching of argumentation, as a tool for teachers to gain an increased understanding of discourse in their own classroom (Osborne et al., 2004) and the epistemic nature of their own discipline (Simon et al., 2006). It has also been introduced directly to 12-13 year old school pupils as part of nature of science and science literacy topics (Simon et al., 2006). In Osborne's (2004) words: "the use of these features of TAP offer teachers a richer metalanguage for talking about science and for understanding the nature of their own discipline" (p. 1015). Here, Osborne refers to the detailed elements of Toulmin's pattern (see below), as opposed to the more general (less specific) terms "ideas" (claims) and "evidence" (data, warrants etc.). Hence, TAP allows for the instruction of argumentation in a way that explicates the rhetorical elements of an argument as it is commonly used in natural settings (Driver et al., 2000; Toulmin, 2003). The essential parts of an argument according to Toulmin are

Claim	– the assertion/specification put forth (here: the culinary precision).
Data/facts	– facts given in support of the claim.
Warrants	– which provide the connection between data and claim.
Backings	– assumptions commonly agreed upon which support the warrant.
Qualifiers	– special conditions under which the claim holds true.
Rebuttals	– statements that contradict either of the other elements.

Revisiting Figure 1 (middle part) it can be seen that this is exactly what is used as link between the left hand and right hand sides in the model by Roberts and Gott (2010). TAP thus constitutes a bridge between, on the one hand, practical work and science content knowledge, and on the other hand the specific subject matter as a socio-scientific issue.

2. The “Kitchen stories” concept

In 2009, a project was started at Volda University College in order to approach inquiry and argumentation in a more explicit manner than previously for undergraduate pre-service teacher students in the two mentioned subjects (Fooladi, 2010). This project, named “Kitchen stories”, draws inspiration from a field within food science, molecular gastronomy, and uses what has been termed “culinary precisions” (This, 2005) as approach to teaching argumentation and inquiry. A culinary precision can be defined as “the technical or procedural information present in a recipe (oral or written), which provides added value in terms of improved quality and greater chance of a successful product” (Fooladi & Hopia, 2012, p. 2). Examples of culinary precisions are

- You can’t make jelly containing fresh kiwi because then the jelly will not set.
- Cucumbers decay/rot more quickly if stored together with tomatoes.
- Leavened bakery will rise more if baked on high (flow) tide compared to ebb tide.

The research design of the project draws inspiration from Design-based research in which a research-based teaching sequence is designed, implemented and analysed (e.g. Cobb, 2001; Edelson, 2002; Juuti & Lavonen, 2006). Throughout the process data is collected by various means such as observation, interview, student text analysis and tests/questionnaires. The teaching sequence is then revised (re-designed), another cycle is conducted and so forth. At the moment of publication the project is in its fourth cycle.

2.1. Practical approach in the “Kitchen stories” project

The concrete approach to culinary precisions used in teaching pre-service teacher students in this project is as follows:

First phase (2–3 weeks duration)

Step 1 – Collect and document culinary precisions
The students can find culinary precisions by interviewing family, professionals (e.g. chef, supermarket employee, artisan etc.) or others, they can search in literature and cookbooks, food pages on the internet and so forth. The source of each culinary precision must then be documented and located in space and time (where it was found, when it was published or stated). Each student must collect at least four culinary precisions. The students must also decide whether it would be possible to test the precision through experiment.

Step 2 – Analyse and construct plausible arguments for a few selected precisions

The group selects one precision/claim for each group member for closer analysis: What does the precision actually claim? What subject matter or evidence is hidden behind this claim? Are there facts and justifications that support, weaken or contradict the claim? Here, TAP is introduced for explicit teaching of argumentation and students are required to apply it when structuring their argument.

Second phase (2–3 weeks duration)

Step 3 – Test/experiment analysed precisions

Each group selects one or two of the analysed precisions for experimental testing. Based on their prior analysis the experiment has to be designed in detail and carried out accordingly.

Step 4 – Record and publish results for benefit of the society and documentation of cultural heritage

The students must record and publish the culinary precisions, analyses and experimental results thus disseminating science with direct relevance to members of the society, while at the same time securing cultural heritage. A culinary precision handed down orally can in some cases be experiential knowledge that would otherwise have been lost unless the students had collected it. This is done by publication in a wiki[1].

2.2. A concrete example: You can’t make jelly containing fresh kiwi because then the jelly will not set

Below follows a description of how a group of four pre-service science teacher students carried out part of their project based on the structure given above. The sample is taken from the first design cycle which was carried out in 2009. Note that this might be adapted to different educational levels as long as modifications are made to suit age group, availability of equipment and so forth, one example being Vartiainen, Aksela and Hopia (2013) who have described the use of culinary precisions as approach to inquiry in lower secondary school.

First phase (3 weeks)

Step 1 – Collection and documentation: The group collected 18 culinary precisions from various sources. The precisions were listed in a document together with their respective sources. Among these, four were selected as promising canditates for close analysis (claims which are difficult to test due to methodological obstacles or lack of resources are usually ruled out, such as health claims, traditional rules for slaughtering animals and so forth).

[1] http://kitchenstories.info/wiki

Step 2 – Analysis: The students attended lectures about argumentation including an introduction to Toulmin's rationale and argumentation pattern. The students had to collect data/facts, warrants/reasons, rebuttals etc. and contruct a complete and plausible argument, see Figure 2 (although the layout differs slightly this diagram is equivalent to the one shown in middle section of Figure 1).

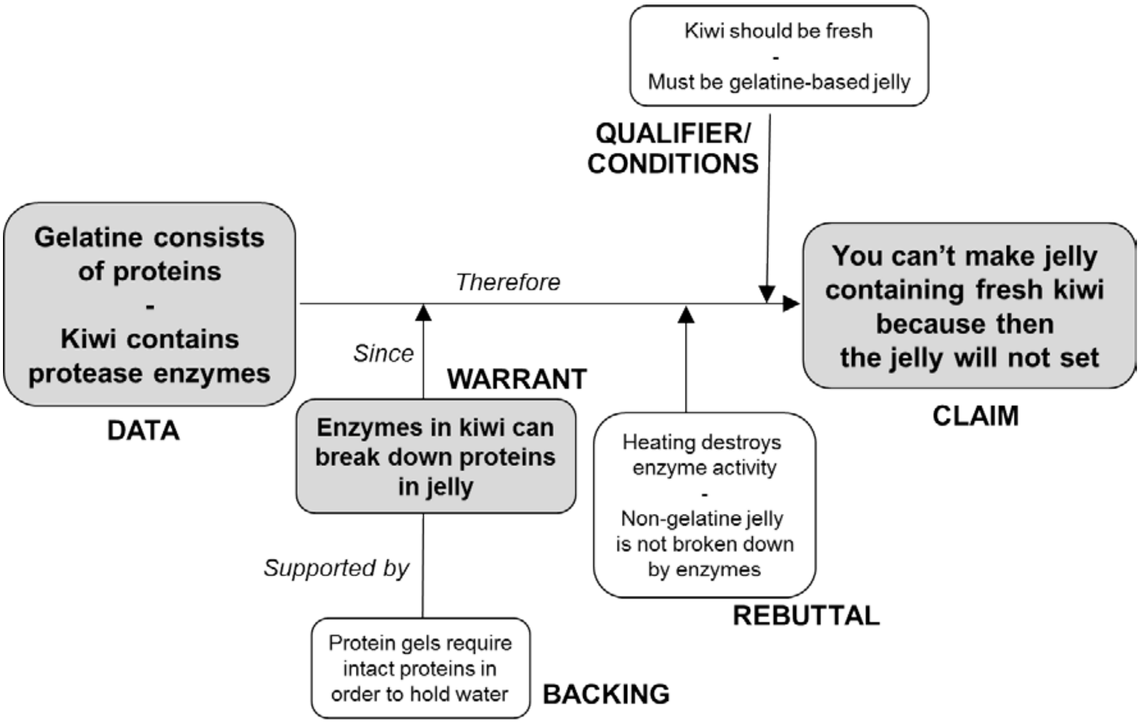

Figure 2. Example of TAP applied on a culinary precision about making jelly with fresh kiwi. The TAP was completed, starting from only the claim, using inference, scientific content knowledge and experiment.

Second phase (3 weeks)

Step 3 – Experiment: Through the data collection process and argumentation the students decided that the claim about kiwi in jelly was also suitable for experimental testing. The hypothesis was: the jelly does not set because protease enzymes in fresh kiwi break down the gelatine proteins in jelly. Since enzymes lose their functionality when heated, blanching[2] the kiwi might render the protease enzymes inactive and hence the jelly would set properly. Furthermore, there are two sorts of jelly in Norwegian grocery shops: standard jelly based on gelatine (a protein) and fast-setting jelly based on locust bean gum (a carbohydrate). If the problem is actually due to proteases in kiwi, which are only able to degrade proteins, the jelly should set properly when using the fast-setting jelly. Figure 3

[2] Blanching is a method in which food is immersed for a brief time in boiling water and immediately plunged into ice cold water. The reason for blanching a food might vary depending on the food and its use.

elegantly demonstrates how the different parallel experiments shed light upon this argument.

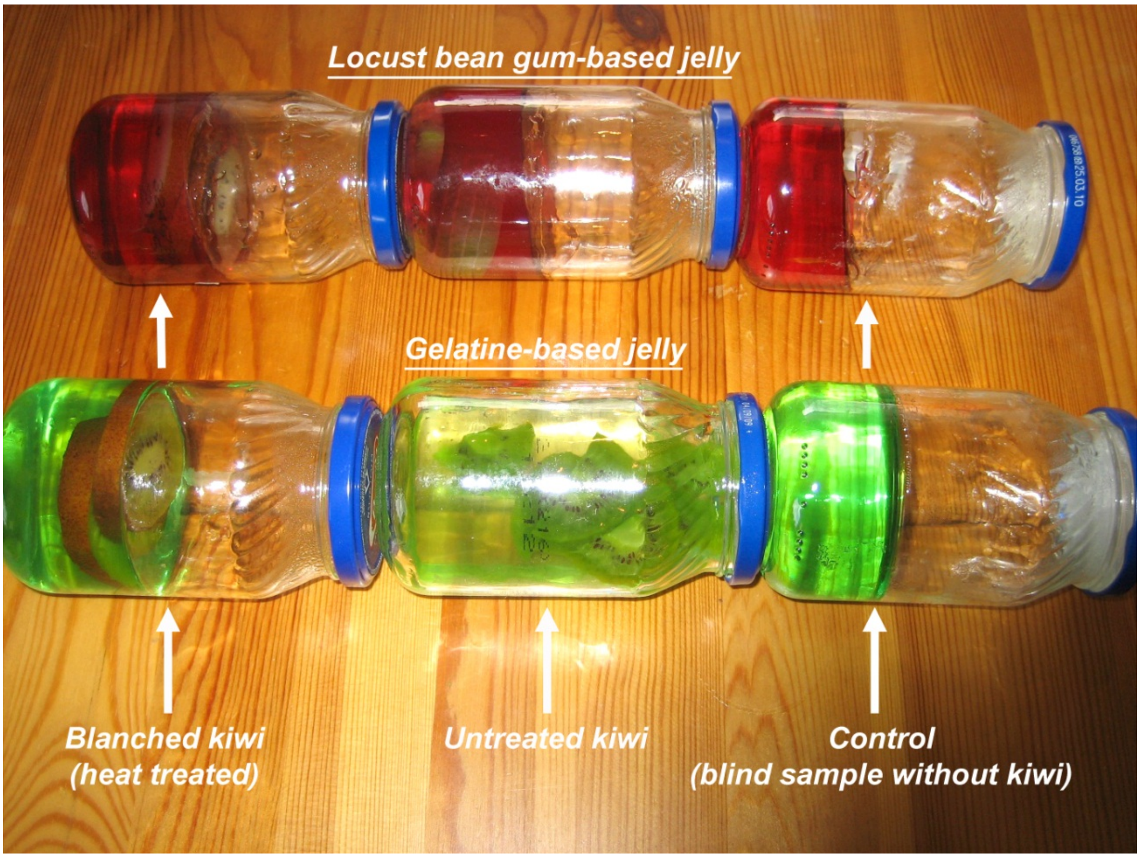

Figure 3. Jelly with kiwi. (Photo: Dagfinn Bakklund)

Step 4 – Documentation and publication: The students were introduced to the IMRaD structure of writing scientific papers,[3] a structure which has dominated as template for writing scientific papers in several sciences (Sollaci & Pereira, 2004), and their report had to be written following this structure. This first year of implementation the student projects were not published, the following years the final projects have been published in a wiki openly available on the internet[1].

[3] IMRaD is an abbreviation for Introduction, Methods, Results and Discussion.

3. Results and discussion

3.1. Research questions

Some research questions from this educational project have been:

- To which extent is it possible to consider culinary precisions as parts of formal arguments, seen from an epistemic or argumentation theoretical perspective?
- Can culinary precisions be used as approach to teaching about argumentation?
- To which extent is TAP a suitable tool in dealing with culinary precisions, be it educational or as a heuristic in structuring kitchen stories as arguments?
- In what sense can culinary precisions be used to promote inquiry activities in science and home economics?
- Which other relevant topics, if any, do appear in the process of collecting and exploring culinary precisions?

3.2. Observations, preliminary results and discussion

Initial results and the accompanying discussion are based on systematic observations, evaluation of student assignments, as well as experiences through design, implementation and revision of teaching sequences. However, rigorous scientific analyses of the collected data are still to be carried out, and the results must hence be considered as preliminary.

3.2.1. Culinary precisions, TAP and argumentation instruction

Through the project it is evident that it is possible to use TAP in the exploration of culinary precisions, consequently supporting the hypothesis that it is possible to construct formal arguments based on culinary precisions. Although the undergraduate students report it to be intellectually demanding, they are able to use this tool for structuring arguments and all groups were ultimately successful in producing coherent arguments. This despite the fact that TAP is said to be difficult to apply in analysis of real life verbal data (Erduran, Simon, & Osborne, 2004). However, as opposed to verbal data Kitchen stories deals with arguments of a different kind and might thus be an arena where TAP is easier to apply with a positive contribution to argument analysis; in the study of verbal data TAP is used to *deconstruct* an argument (e.g. Erduran et al., 2004), whereas the role of TAP in Kitchen stories is to *construct* an argument. The student groups involved in this project have been mixed groups with respect to subject as well as academic achievement levels. However, all groups were able to construct TAPs, but lower achieving students requiring more guidance than higher achieving (groups received 1–2 sessions of supervision for each two-three week phase). A challenge arising in this context is that one single culinary precision might have different sets of facts, warrants, rebuttals and so forth. Consequently, in order to dig deep into a culinary precision one might either have to build several TAPs, rather than only one, or produce one quite complex TAP. However, thus far it is probably not possible to take a qualified stance to the deeper epistemic and argumentation theoretic aspects of this based on the data at hand.

3.2.2. Promoting minds on as well as hands on practical work

A common problem when carrying out practical work (e.g. lab work) is lack of coherence between on the one hand the practical work/experiments and on the other hand content knowledge, scientific methods and scientific ways of thinking (Abrahams & Millar, 2008); in essence, achieving high quality "minds on" practical instruction. In the Kitchen stories project this pattern is turned upside down because the students spend much time asking questions, discussing, searching and conducting second-hand inquiry (Palincsar & Magnusson, 2001) *before* the actual experiment is planned and conducted. Hence, the occurrence of genuine "minds on experimenting" seems to be the common result rather than the opposite way around. Furthermore, no group (total of 21 groups in the three first implementations) has thus far had serious problems finding researchable claims among the culinary precisions they have collected. However, each group needs to collect a sufficient number of culinary precisions in order to have a large enough collection to select from.

Using TAP seems to scaffold the students' inquiry in a positive manner and they apparently adopt a shared lexicon and structure of argumentative reasoning, which has been among the main purposes of the project. Notably, when students were offered the hypothetico-deductive method as support,[4] they reported that TAP and the IMRaD structure combined was sufficient scaffold in order for them to carry out their project. The products from the student work, as assessed by the lecturer, support this notion.

3.2.3. Epistemic status: source awareness and sourcing skills

As members of society in the last decades have been bombarded with increasing amounts of information, awareness and evaluation skills related to trustworthiness and credibility of information sources have become increasingly important among both experts and the general citizen (e.g. Bråten, Strømsø, & Salmerón, 2011; Norris & Phillips, 1994; Wellington & Osborne, 2001). In the Kitchen stories project the students naturally use a broad selection of information sources in addition to the course textbooks. After the first round of implementation it became evident that source awareness was an important matter to consider, and this was one of two major revisions in the design between first and second cycle. Hence, a source credibility step was introduced in which the students were to rate

[4] The hypothetico-deductive method, HDM, is a commonly used methodology for project work in Norwegian schools supported by an educational outreach project through the Research Council of Norway, "Nysgjerrigper" (Research Council of Norway).

every source they used along one of two scales. If a source, in some way, was considered to be of a scientific nature the students had to rate it on a six point scale between 1 (lowest, e.g. internet with no other references, otherwise undocumented old wives' tale) and 6 (highest, e.g. scientific literature on international level).

However, the source could be a more or less experienced craftsperson in which case rating along a scale of scientific credibility might not be appropriate. These sources were rated along a scale between A (lowest, no relevant experience) and F (highest, e.g. an expert chef or artisan). In evaluating the sources, the students themselves had to choose whether a source should be rated along the scientific or craftsmanship scale or both. The students also had to rate their own experiments along either of these scales since their experimental results constitute a part of the final argument. Hence, a byproduct of the Kitchen stories project has been not only an increased focus on a wider selection of information sources compared to only textbooks, but also a strong emphasis on *epistemic status* of information which has been an increasingly important topic in science education the latter years. The context afforded by home economics in in this respect unique since it represents a meeting point between science and craftsmanship in a setting from everyday life.

3.2.4. Kitchen stories and declarative knowledge

One potential problem introduced through this project is that the teacher has limited control over which declarative knowledge is covered, at least if the students select freely among the collected precisions. Vartiainen et al. (2013) have shown that a number of relevant chemistry topics do arise naturally in the process, as is also observed in the project herein. Hence, Kitchen stories afford ample opportunities for teaching declarative knowledge in addition to the mentioned procedural knowledge and reasoning. If high control over what declarative knowledge is covered is required, working from predefined claims in a less open process would be an option to consider.

4. Conclusions

Reconsidering Roberts' model of science in society (Figure 1) we might say that in Kitchen stories the participants start out by looking back (from the societal perspective) retracing, or "unpicking", possible arguments for a certain claim. The students must then assume the role of the researcher and start looking forward: based on their constructed argument they must draw up an experimental design, carry out the experiment and move all the way to the right through a coherent argument ending up with a publication related to the societal issue at hand (Figure 4).

Through this process the students have encountered real-world questions, dealt with argumentation in an explicit manner, designed and carried out one or more experiments, documented results based on evidence from own experiment as well as second-hand sources in an argumentative manner, and finally conveyed their findings to a real public. Furthermore, the students are part of a project in which data is collected for the common good of society; in a sense they assume the role of true researchers and not only students.

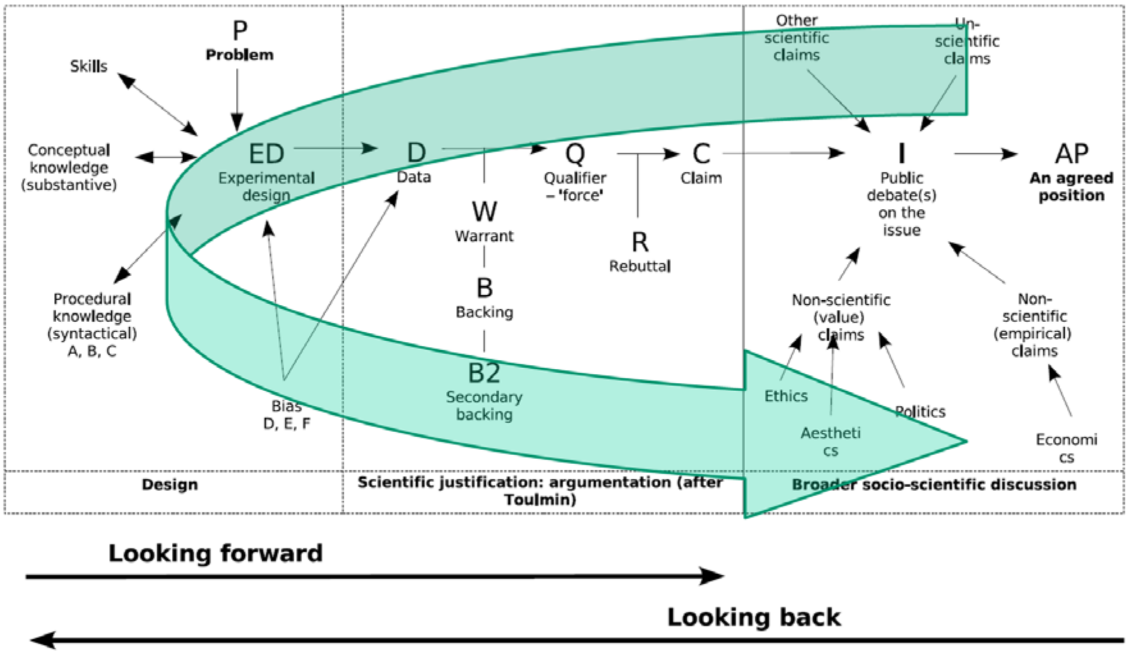

Figure 4. The process in a Kitchen stories project, with participants starting from a culinary precision "looking back" along the line of plausible argument and evidence. This is followed by the opposite approach "looking forward" as the students assume the role of a researcher.

5. Outlook

A matter that would benefit from further studies is the epistemic aspects of this multidisciplinary setting. The possible tension between, and the possibilities afforded by, on the one hand scientific knowledge and methods and on the other hand the epistemic characteristics and values of experience-based food and cooking (craftsmanship) represents a highly relevant matter when seen in the context of science in society. In dealing with culinary precisions, science does not always have the one true answer. One example is the fact that it was possible for Vega and Mercadé-Prieto (2011) to publish a scientific paper on the texture of boiled eggs as late as in 2011, a matter which has been of debate and practical study in homes and restaurants for centuries! This illustrates that science is in constant change and development, a fact which is often overlooked in school science (Abd-El-Khalick & Lederman, 2000; Vesterinen, Aksela, & Sundberg, 2009). One way to approach this would be exploring possibilities for adapting Kitchen stories, or more generally culinary precisions, at various educational levels from primary school all the way through tertiary education. Examples of efforts do exist in France[5] as well as in Finland (Vartiainen et al., 2013), but educational research on the matter is scarce.

Finally, culinary precisions do constitute a unique arena for the interaction between science and society. At the present, an open invitation has been issued in which anyone with an interest in culinary stories, narratives, and claims as a source of shared knowledge and cultural identity are welcome to join a network of affiliate members (Fooladi & Hopia, 2013). The network is multidisciplinary (e.g. food science and molecular gastronomy, history and ethnology, sociology, home economics) and the members represent a broad range of occupations (scientists, teachers and educators, food writers and communicators, chefs, students, industry and businesses, and food devotees). In using this common interest, work is underway to stimulate a closer interaction between science and society also including education at all levels. Anyone interested in joining the network, currently in the shape of a mailing list, are thus invited to contact us for further information.

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[5] http://www.inra.fr/fondation_science_culture_alimentaire/les_travaux_de_la_fondation_science_culture_alimentaire/les_divisions/division_education_formation/ateliers_experimentaux_du_gout

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