PUBLIC FINAL REPORT

A) Project Data

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Project Web Site:	www.modul.ac.at/nmt/triple-c
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B) Project Overview

1 Executive Summary

The Climate Change Collaboratory (Triple-C) has built tools to strengthen the relations between environmental stakeholders who recognize the need for climate change adaptation and mitigation, but differ in their specific worldviews, goals and agendas. The collaboratory provides tools to manage expert knowledge and a context-sensitive environment for creating and editing documents in a collaborative manner. The user's context is provided by a real-time synchronization framework for rendering information landscapes, geographic projections, and ontology graphs. Innovative survey instruments in the tradition of "games with a purpose" were used to create shared meaning through collaborative ontology building, and to capture indicators of climate change knowledge. Two project workshops helped align Triple-C with the research activities of its associate partners, increase the project's visibility, and foster collaboration with leading international organizations.

Triple-C addressed the interdisciplinary problem dimensions of climate change and the call to "coordinate and strengthen existing climate research in Austria, and integrate it better into international research networks". The developed technologies provide added value for stakeholders at various levels: At the micro level, they offer a unique approach to capture climate change knowledge. At the macro level, they contribute in several ways to understanding stakeholders' motivations and agendas. The collaboratory addresses the requirements of participating core and associated partners through a Web-based retrieval and collaborative authoring environment. The project's analytical services facilitate the analysis of stakeholder communication. Identifying patterns increases transparency, builds trust, and reduces uncertainties on the individual and group level. Triple-C supports climate change communication on several levels, both among stakeholders and between stakeholders and their target audience. *Games with a purpose* coupled with *dynamic questionnaires* were introduced as a unique and cost-effective way to increase awareness, trigger participatory processes and capture social data from large user communities. For policy makers, the Climate Change Collaboratory represents a unique window to witness interactions between stakeholders, understand their positions and intentions, track the emergence of topics and unfolding social processes, as well as to judge the effectiveness of communication policies and incentive mechanisms on individual and organizational levels.

2 Background and Goals

The main motivation behind the Triple-C project was to harness and amplify the collective resources of stakeholders, rather than merely building a Web portal to provide climate-related information. Triple-C targeted organizations already working on climate change adaptation and mitigation, empowering their employees to work and communicate more effectively. State-of-the-art semantic Web technology provides an unprecedented level of transparency and identifies the most relevant information from various sources at the touch of a button. Guided by the feedback gathered during a kick-off workshop, the deployed technology has been made available to the public. It considers the strategic interests of associated partners and other stakeholders – who, in many cases, successfully operate Web sites themselves, and played an important role in capturing consumer data through embedded interactive Web applications in the tradition of "games with a purpose" (small Web applications with a built-in set of incentive schemes that encourage people to participate in productive processes).

Triple-C technology builds capacity among policy makers, scientists, educators, environmental NGOs, news media and corporations, helping to create and manage environmental online resources more effectively. It represents an interdisciplinary initiative to encourage and study discourse and critical debate that lead to a shared understanding of climate change issues on various levels, ranging from inter-individual communication and local communities to global campaigns and treaties.

Unearthing hidden assumptions and misconceptions about climate change contributes to a mutual understanding of existing problems, and suggests priorities for research and policy development. Participants in the collaboratory benefit from a synergy of skills and resources, flexible and non-hierarchical modes of cooperation, and the constitution and dynamic maintenance of shared knowledge.

3 Scope and Results of the Project

KICK-OFF WORKSHOP

One of the main deliverables in the first year of the project was the kick-off workshop, which was held on 16 June 2010 at MODUL University Vienna. The event included a closed workshop with consortium members and invited external experts (attended by eighteen experts from Europe and the United States), followed by a public event during which several presentations were given and a subsequent panel discussion was held on the topic "Climate Change Communication and Collaboration: Translating Awareness into Collective Action".

The invited experts not only helped to compile a detailed list of requirements, maximizing the added value for all involved organizations and taking into account their strategic interests, but also promised to assist in dissemination activities once a prototype became available. It quickly became clear that the existing stakeholders urgently require tools to build capacity and support the maintenance of their existing communities in an ad-hoc manner, rather than a new community of practice. Based on this feedback, early project tasks focused on capturing new data sources such as publications and science news, and providing a context-aware collaborative authoring environment as outlined below.

The preparation of the workshop included activities regarding the selection of speakers, organizing their travel, room and board, and coordinating a book presentation on sustainability and climate change during the event. Following the kick-off workshop itself, a fourteen page workshop summary was produced with detailed information on the project, the involved participants, and the proceedings of the workshop. The European Support Centre of the Club of Rome ESC (CoR ESC) coordinated the publication of a booklet with eleven articles contributed by an equal number of individuals who participated in the workshop, as well as several additional co-authors.

PROJECT WEB SITES

Information related to the project was conveyed through three different Web channels: (i) the official project Web site at www.modul.ac.at/nmt/triple-c, summarizing the goals of the project, the composition of the consortium, and regular news and progress updates. (ii) a project summary on the ECOresearch Network Web site (www.ecoresearch.net/triple-c), announcing the project to the existing community; and (iii) the developed improvements and knowledge co-creation extensions of the Media Watch on Climate Change (www.ecoresearch.net/climate).

ONLINE QUESTIONNAIRE

Collecting international and intercultural data on individual climate change knowledge currently demands considerable efforts. Individual scores in the "game with a purpose" reflect the ability to replicate prevailing categories and interrelations of climate change topics. Game scores therefore might provide an innovative alternative for measuring climate change knowledge. Games with a purpose obtain data from large worldwide samples in a cost-efficient, unobtrusive and continuous manner.

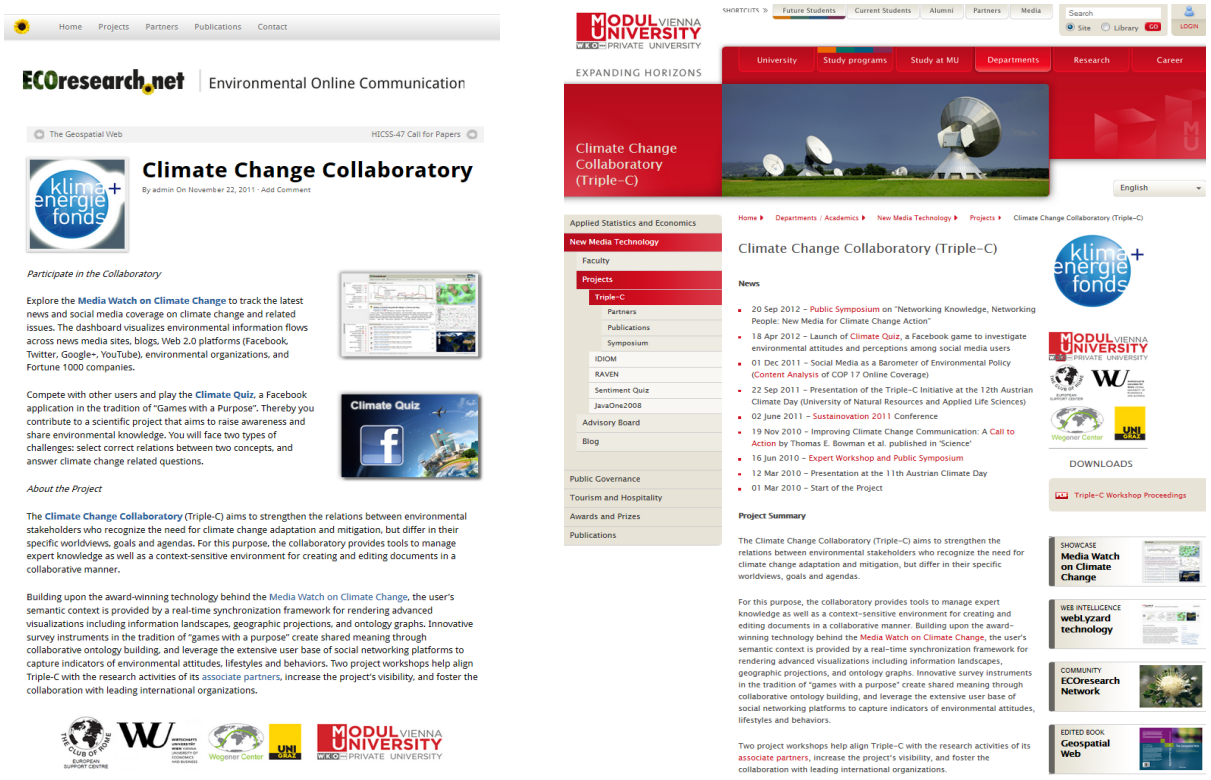

Figure 1. Screenshots of the ECOresearch project reference and the official project Web sites at www.ecoresearch.net/triple-c and www.modul.ac.at/nmt/triple-c, respectively.

To evaluate the potential of game scores as a survey tool for climate change knowledge, the project team needed to establish validity (does the instrument indeed measure what it is supposed to measure?) and representativeness (which population groups can be reached by the instrument?).

- Correlations with quiz questions on climate change establish *criterion validity*. The assessment of the related constructs risk perception and concern about climate change, attribution of responsibility, personal efficacy, subjective knowledge and knowledge on climate change in the personal network verifies *discriminant validity*.
- Control for *non-representative sampling* is available through social statistics (age, gender, nationality, educational level, and political orientation), environmental values and membership in environmental NGOs or lobby groups.

Survey questions on these constructs were compiled from previous studies considering thematic relevance and availability of item characteristics (e.g., item difficulty, factor loadings). Through discussions in the project team and the following methodological steps, this question pool was refined and narrowed down to the final questionnaire:

- Pre-testing among n=50+ persons (students from the University of Graz, MODUL University Vienna, and the Vienna University of Economics and Business, people from the general Austrian population) to ensure comprehensibility and to obtain an indication of the difficulties of climate change quiz questions.
- Check for scientifically proven correct answers on quiz questions by geophysicists at the Wegener Center, and by consulting current IPCC reports. This is why questions on future projections of climate change are excluded from the questionnaire.
- Check for correct and simplified English language by native speakers among the project team. The pre-test showed that English language skills cannot be taken for granted among the general population.

- Factor analyses of secondary data to ensure construct validity, meaning that items of the same construct correlate highly and constitute a common factor. We used publicly available data from the European Value Study 2008 and data from the two fall 2008 waves in the Six Americas Project, kindly provided by E. Maibach from George Mason University and A. Leiserowitz from Yale University. Results from these analyses lead to the elimination of items not clearly allocated to a single factor. Moreover, we found that the distinction between cognitive risk perception and emotional concern is blurry.

Figure 2. Triple-C climate change survey

All items in the final questionnaire used neutral question wording and bipolar response scales. Quiz questions applied a multiple choice format. Easy, intermediate and hard quiz questions were included to ensure good differentiation between respondents. Wherever feasible, item wordings were identical or closely similar to other cross-national surveys (e.g., Eurobarometer, World Value Study, International Social Survey Programme, Six Americas Project) to gain the opportunity for later comparisons with these data sets. To host the online version of the questionnaire on the Web site of the ECOresearch Network, the open source survey application *LimeSurvey* (www.limesurvey.org) was installed on the project server. In conjunction with the Facebook application, it was used to gather international and intercultural data on individual climate change knowledge.

KNOWLEDGE CO-CREATION PROTOTYPE

In the first year of the project, the Triple-C consortium successfully tackled a number of major technological challenges. Moving from a content aggregator (Media Watch on Climate Change) to a real-time authoring environment (Climate Change Collaboratory) entailed a complete redesign of many of the underlying services, in addition to adding new data sources as requested during the kick-off workshop. We extended the set of available data sources (news media, blogs, environmental organizations, and Fortune 1000 companies) by adding two new samples: (i) scientific publications and (ii) science news. The screenshot in Figure 3 shows the results for a query on "climate science" combining news and social media, including keyword graph, information landscape, tag cloud and geographic projection of search results.

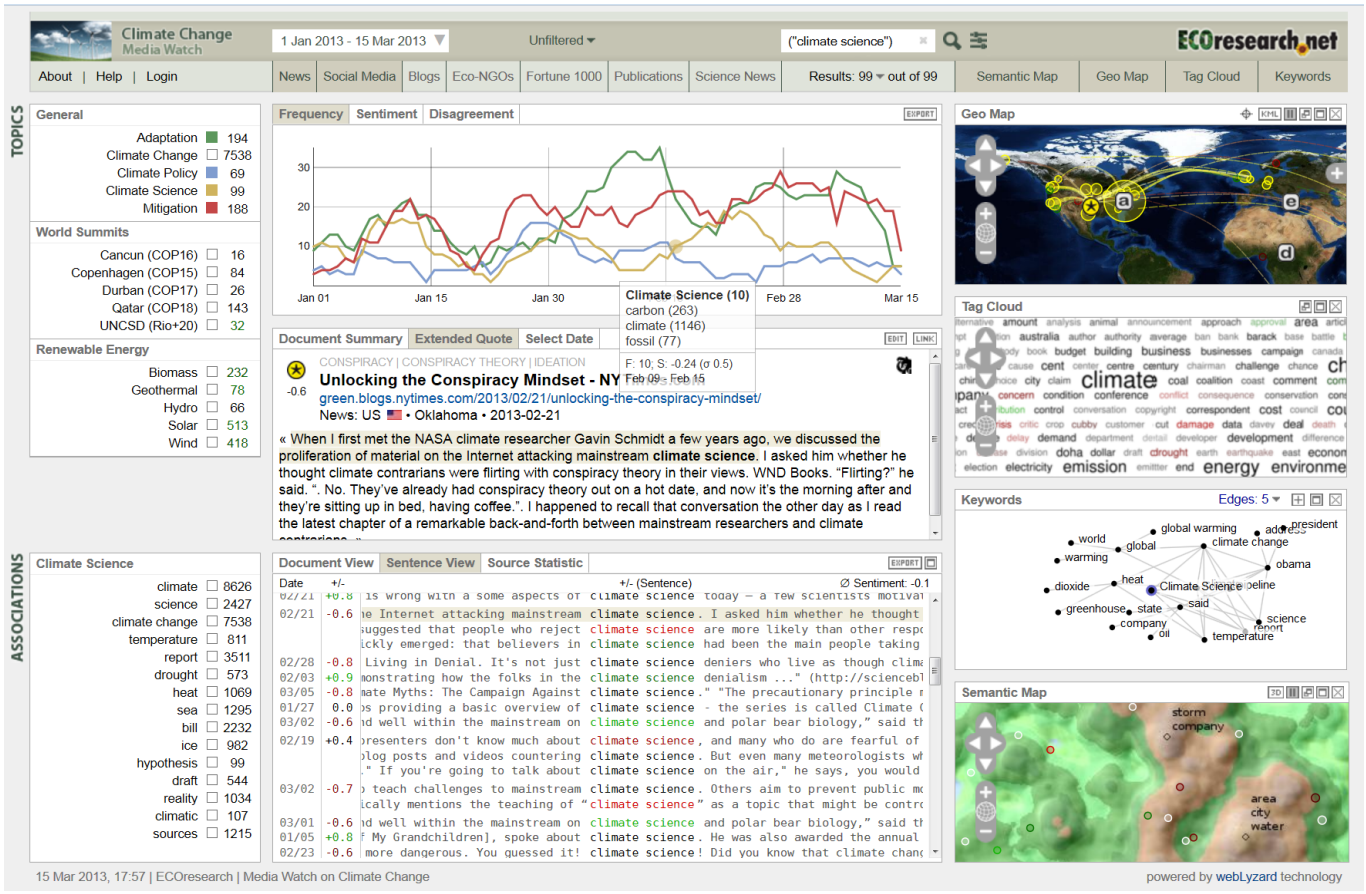

Figure 3. Climate science news and social media coverage between January and March 2013

Scalability and Transparency. The scalability of the annotation and document enrichment processing pipeline had to be radically increased. While a content aggregator usually works in batch mode and faces hourly updates at most, users of real-time editing environments expect rapid response times and no noticeable delays during the authoring process. In the content of Triple-C, the throughput of three services required significant methodological changes: (i) the geo-tagging component to identify geographic references in plain text, match these references to unique locations, and assign geographic coordinates; (ii) the computation of semantic similarity to determine a document's position in the information landscape; (iii) the identification of keywords to label document clusters and explain observable trends in the charts, and (iv) the serving and caching of image tiles for the various visualizations. These improvements had an immediate impact on the prototype, allowing users to hover above the information landscape and geographic map to preview a document in real time (a subsequent click activates the document), and to show keywords in the trend charts when moving the mouse pointer over a particular data point.

Advanced Search. A comparably straightforward to implement request of the invited experts at the kick-off workshop was the provision of improved search capabilities including wildcards and export functionality. The system now supports the usual characters, while the asterisk (*) represents any number of unknown characters and the question mark (?) represents exactly one character. The syntax of additional options (source, location, date, etc.) is described in the advanced search section. Once a user has entered a search query, the system lists all sentences containing the search term and groups them by document. The color of the term reflects sentiment on the sentence level. The column headers allow sorting the quotes by their date of publication, as well as the sentiment on both the document level and the sentence level. By clicking on their publication date, users can select and deselect the documents to be exported via the corresponding button in the upper right corner of the active document view.

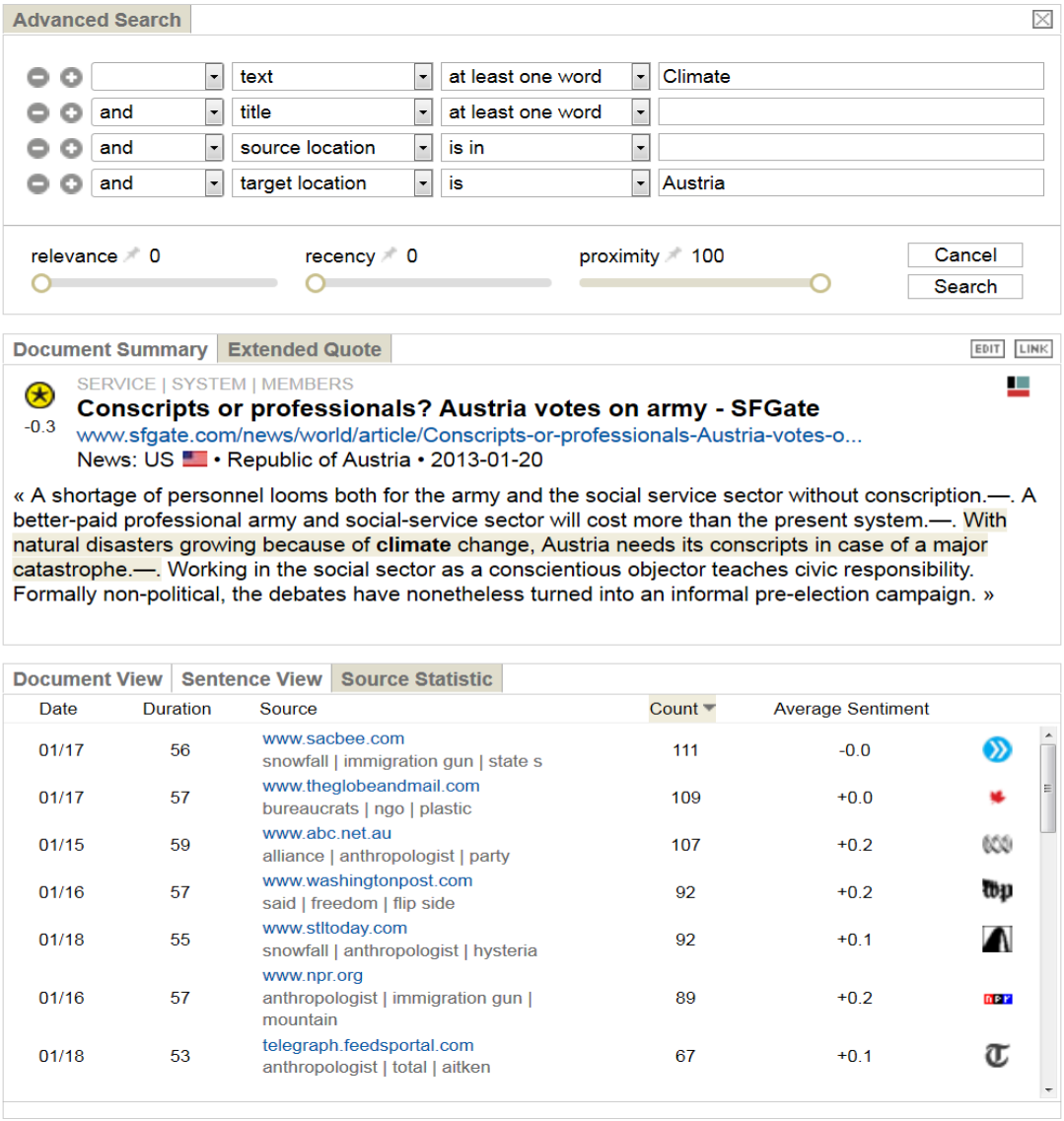

Figure 4. Source statistic on the term "climate" with a target location of "Austria", including a set of sliders to sort search results by relevance, topicality and proximity to a specified target location

Tracking Emerging Trends. The extended system is able to automatically extract the dominant issues that are discussed in conjunction with a selected topic and displays them through a set of charts that show the frequency and sentiment of a topic, as well as the observable level of disagreement among stakeholders. The search results are also mapped on geographic and semantic maps to show the geographic distribution of the coverage (e.g., places most talked about), as well as its semantic context (e.g., number of documents reporting about a specific issue).

The U.S. Election 2012 may serve as a good example to demonstrate these capabilities. The search query for "Barack Obama" in Figure 5, for example, lists *Mitt Romney* and the *Keystone XL Pipeline* as the top two news media associations in the context of climate change between January and November 2012. The screenshot also reveals that the topic of climate change did not receive much attention during the U.S. Elections 2012 (shown by the strong correlation between the two trend lines). The coverage on the pipeline was driven by third parties. Additional, campaign-driven topics would show up as divergence points (the only exception is the minor peak triggered by the *Rio+20 Conference* in June 2012). The notable silence on climate change came to a sudden end once hurricane "Sandy" hit the U.S. East Coast, and New York City Mayor Michael Bloomberg endorsed the incumbent for re-election, citing the threat of climate change as the primary reason for his decision.

To accommodate the reuse of information in external applications, a requested feature during the Triple-C kick-off workshop, the Media Watch was extended by a wide range of export formats for the aggregated social media content including RSS, HTML for textual data, and CSV for time series data.

Collaborative Real-Time Authoring Environment. Once the required scalability and throughput were achieved, the development efforts focused on the actual editing environment. The initial prototype stored the edited document as an HTTP client state cookie, allowing continuous editing of a document while performing other activities in the portal. The required annotations to determine the geographic and semantic context are computed in milliseconds, ensuring a seamless user experience and making sure that the most relevant content (e.g. climate change news media articles and publications) immediately appears across all displayed windows.

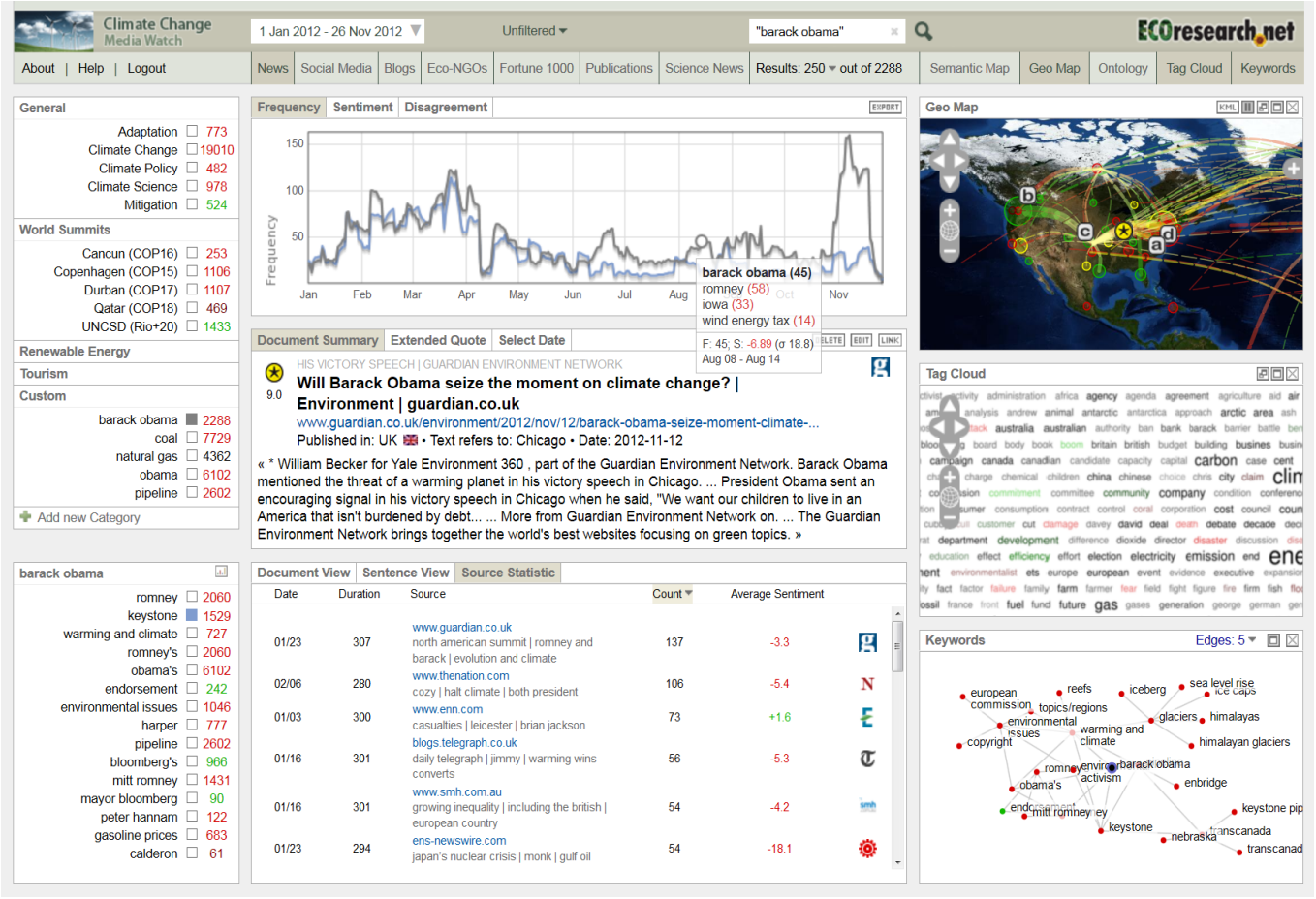

Figure 5. Screenshot of the Media Watch on Climate Change, showing results for a query on "barack obama" from Anglo-American news media between January and November 2012

Development work in the second year focused on multi-user support and showing the continuous evolution of document spaces. Traditional authoring models assume that users first investigate a topic (review the literature, scan the latest news media coverage, etc.), start communicating with their co-authors, and then start drafting and revising the manuscript in either an asynchronous or synchronous manner. The sequential character of these phases and fragmented workflow is not commensurate with the requirements of today's globally distributed, rapidly changing, and agile collaborative enterprises. The Triple-C content recommendations are an important step to merging these distinct phases. They enable an implicit form of information seeking, where the system infers informational needs from the users' actions or opinions, rather than explicit queries. When multiple users jointly edit a document, the system immediately distributes changes to all co-authors and per-

forms background queries for similar documents to automatically recommend relevant information from a customizable set of sources (news media, social media, archives of environmental reports, etc.), as well as appropriate tags to classify the document (geographic location, sentiment, keywords, etc.). These recommendations are made on-the-fly, while users are typing. Documents created with this Web-based and context-sensitive environment become part of the document repository and are being processed together with content from third-party sources. The collaborative editor of Triple-C builds upon the Aloha semantic editing framework (www.aloha-editor.org).

CLIMATE QUIZ

Innovative modes of Web-based interaction enable us to validate and extend ontologies as a by-product of users playing online games, creating an entertaining yet productive setting where large-scale ontology evaluation becomes feasible. Multi-user games with a purpose (GWAPs) capture formal and informal knowledge and communication processes (in the sense of "collective mind mapping"). This reveals the "how" and "why" of the intricate knowledge relations within and across organizations. The *Climate Quiz* developed as part of the Triple-C project leverages the significant potential of social networking platforms and their viral mechanisms for addressing scientific problems. Advantages include a large number of possible players, intrinsic motivation within a social context, and more effective mechanisms to detect and combat attempts of cheating and manipulating results.

Climate Quiz focuses on acquiring knowledge in the domain of climate change as opposed to harvesting generic knowledge. As such, it appeals to environmental enthusiasts and leverages their interest in the domain as an additional motivational factor (besides the fun factor). It leverages the potential of social networking systems, particularly Facebook, for attracting players. A differentiating feature of Climate Quiz compared to other knowledge acquisition games is its pronounced educational goal, a feature resembling virtual citizen science projects..

Application Framework. Climate Quiz builds upon and extends the social application framework of the *Sentiment Quiz*, a publicly available Facebook application and winner of the "Online Communities and Social Networks" category of the Austrian National Award for Multimedia and e-Business. Released as part of the US Election 2008 Web Monitor (www.ecoresearch.net/election2008), the application asked users to vote for and track their preferred candidates, and to evaluate whether quotes from election-related documents expressed positive or negative sentiment. Besides leveraging the wisdom of the crowds to improve algorithms for automated sentiment detection, the system helped investigate perceptions of political Web content. Climate Quiz was implemented in PHP and JavaScript using the jQuery Framework and Facebook's Graph API. Using the Graph API enables a deep integration with the Facebook user experience and allows retrieving information about the user to use them for statistical analysis. When starting the game, Facebook provides a security token to access the information of the user (if the user grants data access to the application). The information is provided via the JavaScript Object Notation (JSON). The jQuery JavaScript framework helped avoid the need for page reloads. This not only improves the user experience, but also yields technical benefits (partial refreshes of a page reduce the total amount of SQL queries and improve the scalability of the application). Climate Quiz uses a Model-View-Controller (MVC) design pattern to allow easy maintenance and extensibility. The data generated by playing the game and the basic information about the users are stored in a PostgreSQL database. The stored data provide rich information about the usage of the game.

Task Structure. Climate Quiz goes beyond the rather simple five-point sentence classification of the Sentiment Quiz, its predecessor. It integrates multiple-choice questions, offers a separate questionnaire as a bonus challenge, and invites Facebook users and their online friends to evaluate whether two concepts presented by the system are related (e.g. "climate change", "ecosystem"), and which label is most appropriate to describe this relation (e.g. "threatens"). The system controls the types of relations between concept pairs; the consideration set of Climate Quiz contains both generic (e.g., "is a sub-category of") and domain-specific (e.g., "opposes") relations.

Between the aforementioned game tasks consisting of a term pair and an ontological relation, quiz questions are interspersed. In total, 22 quiz questions are given in random order during the initial stage of the game, so that every second game task is followed by a quiz question. In contrast to the 'wisdom of the crowd' criterion for gaining points in game tasks, all quiz questions have just one predefined correct answer. Similar to game tasks, players gain one point for answering correctly, and lose one point for a wrong response. Once all quiz questions are answered, players receive an invitation to complete an online questionnaire worth 50 additional points.

The game score reflects the ability to replicate prevailing categories and interrelations of climate change topics. Although there are no explicitly correct or false responses to game tasks, but rather only responses which do or do not reflect the opinion of the majority of players, an individual's game score might nevertheless be an indicator of his climate change knowledge. The total quiz score from the quiz questions serves as a criterion for climate change knowledge.

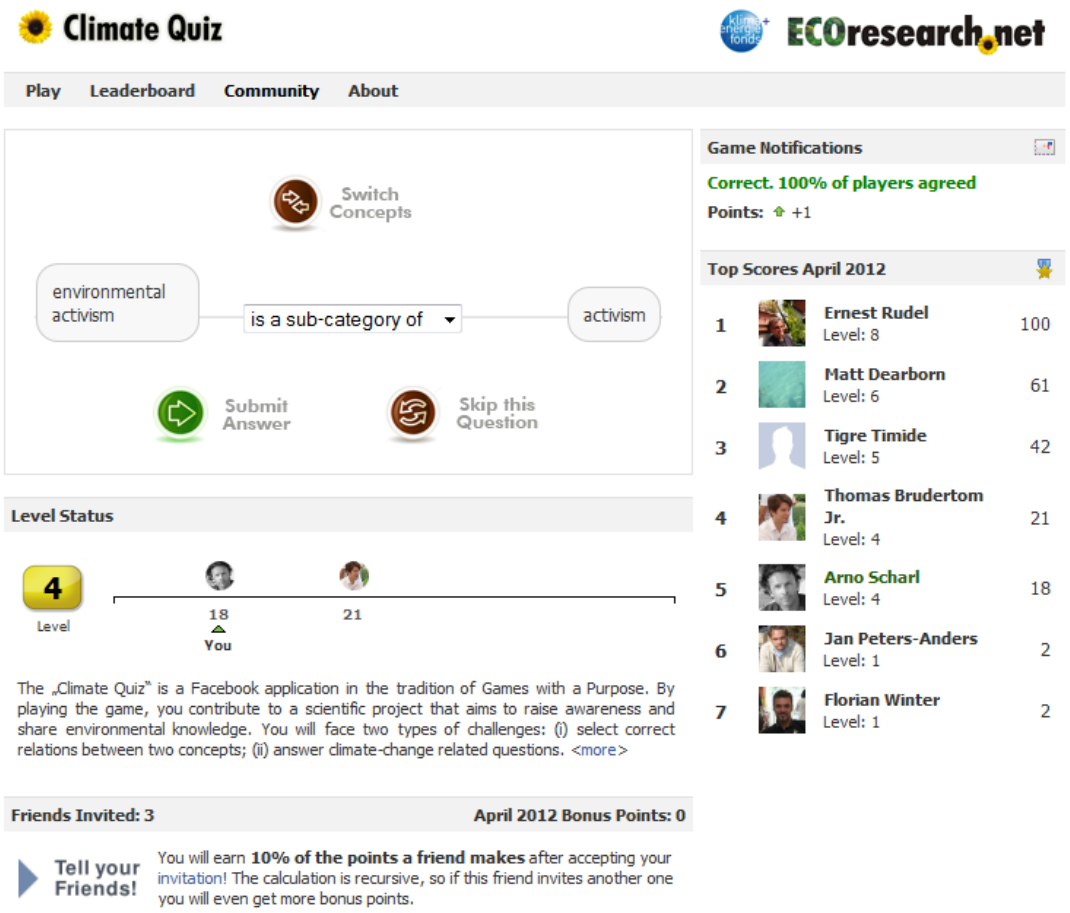

Figure 6. Climate Quiz Relation Assessment

To extract the environmental concepts from Anglo-American news media coverage between January and December 2011, the project used a component for semi-automated ontology learning from unstructured text, which has been continually refined over several years as part of the webLyzard text mining framework (www.weblyzard.com). It incorporates a range of methods from statistics, artificial intelligence and natural language processing, including co-occurrence analysis, subsumption analysis, link type detection, Hearst patterns, and spreading activation. It addresses the limited availability of expertise and qualified human resources, which is the bottleneck and cost-driver in building environmental ontologies. Automated suggestions and intuitive interfaces address this bottleneck by improving the productivity of ontology engineers. Deconstructing the complicated task of ontology building into tiny problems that can be solved by a wider community also offsets the lim-

ited availability of domain experts (the Climate Change Collaboratory does not intend to create an ontology editor; it aims at developing applications with simple and rapid user feedback mechanisms to interact with highly dynamic, evolving climate change resources).

Built-in notification systems and real-time progress statistics help engage Facebook users and leverage the wisdom of the crowds for scientific purposes. Participants earn one point for each matching answer, but can also lose points if their opinion differs from the majority of players. If in doubt, the system awards a point in order to not discourage players – if the first user selects relation A, for example, and the second user selects B, both receive a point since a majority solution has yet to be determined. If the first two players have answered A, however, the answer of a third player who does not agree with them is considered wrong.

Participants are given immediate feedback in terms of the percentage of players who agreed/disagreed with their decision. This feedback constitutes a continuous training mechanism throughout the game, and increases transparency by explaining how the points are provided.

To attract a sufficient number of players, we used a combination of press releases, presentations (e.g. at an online conference organized by the World Bank's Connect4Climate initiative), paid Facebook ads, and personal networking. To maintain and grow the resulting community of players, incentives include a leveling system with the opportunity to unlock additional games features, the comparison of a player's performance vis-à-vis her or his network of online friends, and the leaderboard shown in Figure 7 with monthly scores and progress statistics.

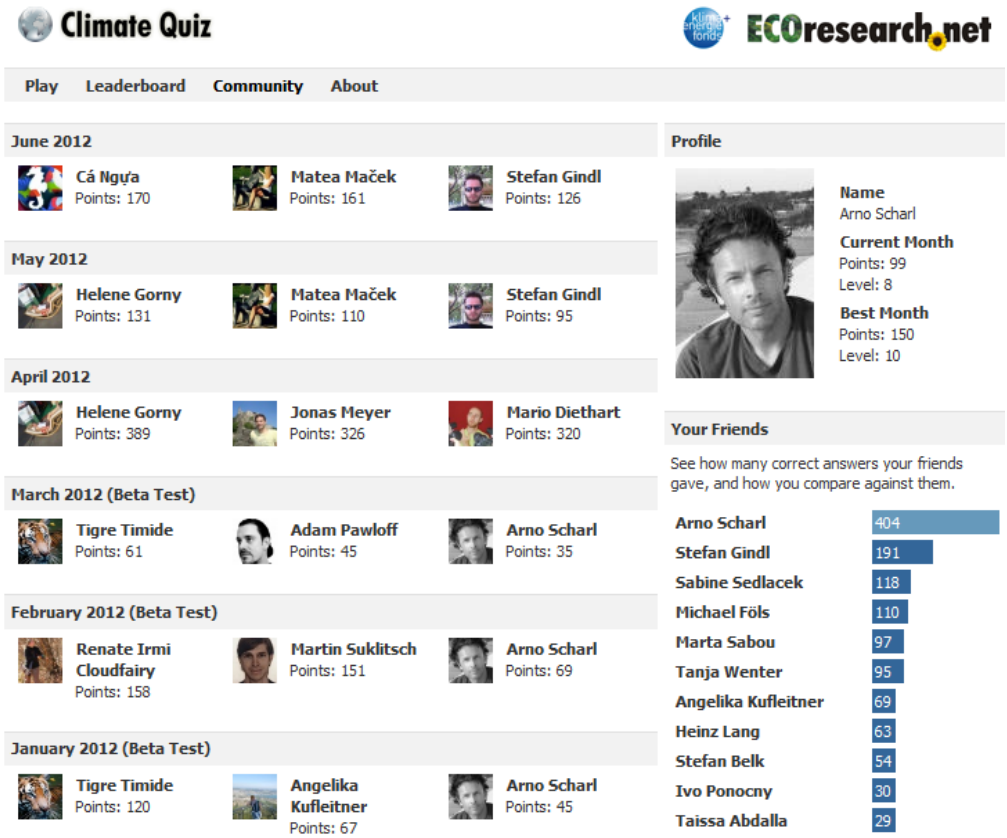

Figure 7. Climate Quiz Leaderboard

Usage Statistics and Results. *Climate Quiz* was launched on 18 April 2012, together with a dedicated community page to assist the dissemination process. Within the first week, a total number of 275 users had played the game, generating 7,836 ontology relations and 1,563 survey answers. Of these 275 players, 222 had become returning visitors; 171 (120) of them returned for at least five (ten) times. Until the end of October, the total number of players had increased to 648, yielding

19,896 ontology relations and 3,871 survey answers. Of these 648 players, 532 have become returning visitors; 409 (310) players returning at least five (ten) times. A high level of user engagement is reflected by a typical game session lasting an average of 10.33 minutes, some for over an hour. The average speed in which players are answering is 19 seconds per ontology relation and 27 seconds per survey answer. 47 users filled out the add-on survey after solving all multiple choice questions in order to get 50 bonus points in the game. A total number of 1,213 distinct concept pairs were assessed between April and October 2012. A final relation could be identified for 424 of these concept pairs. The other pairs remain in the game and require additional user interactions to confirm the majority opinion. The demographic structure is an important element of dynamic user modeling. The *Climate Quiz* gender distribution shows 325 male and 303 female participants (the other participants did not provide the information in their Facebook profile). The average user is 32.6 years old (the oldest is 81 years old, the youngest 14 years). As shown in Figure 8, a majority of 353 users have English set as their default language, followed by German (229), Spanish (19), and French (6). In terms of geographic location, the most frequently mentioned home cities are Vienna (72), Graz (62), Innsbruck (7), Dublin (6), Zagreb (4), and New York (4).

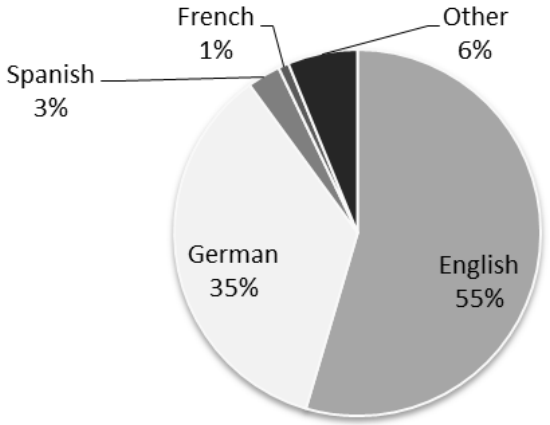

Figure 8. Default Language of Participants (n=647)

Climate Quiz represents a prototypical attempt of a serious game for assessing climate change knowledge. The serious game format circumvents costly and self-aware survey settings, and allows collecting repeated measures from the same individuals. Analyses of game statistics and questionnaire data successfully verified the game point score as a measure of climate change knowledge, establishing reliability, criterion validity and discriminant validity. The game score does not perfectly represent climate change knowledge (criterion validity: r=.29), but should be accurate enough for many research questions which rely on continuous and current data.

FINAL WORKSHOP

The main aim of the final workshop of the Triple-C project was to launch the Climate Change Collaboratory and present the project's key outcomes. The workshop started with a presentation of the project, followed by a live demonstration of the collaboratory's capabilities. The following first of two rounds of presentations and group discussion focused on the need for improved communication of science and the environment, particularly with regard to policymakers. The presenters looked at both the issues that they have faced in the communication of science to diverse audiences as well as potential solutions, scientific perspectives regarding the problem and the role that technology could play in bridging the gap. The second group of presenters explored existing and future technological tools and their potential for improving the communication of science and the environment. Presenters were experts and practitioners in the use of technology for the visualization and communication of complex issues. The focus of the presentations ranged from serious games to online education, from satellite imagery to network analysis. In the final segment of the workshop, participants discussed ways in which the tools developed by Triple-C could be utilized in the future in order to im-

prove the communication of climate change, as well as discussed concrete opportunities for collaboration. It also covered further development of Triple-C methods and cross-cutting themes. One of the key aims of the discussion was to identify ways in which word could be spread about the developed tools, and suggestions of how they could best be applied.

4 Conclusions and Recommendations

The Climate Change Collaboratory (Triple-C) built tools to manage expert knowledge as well as a context-sensitive environment for creating and editing documents in a collaborative manner. Building upon the award-winning technology behind the *Media Watch on Climate Change*, the user's semantic context is considered by a real-time synchronization framework for rendering advanced visualizations including information landscapes, geographic projections, and ontology graphs. Innovative survey instruments in the tradition of "games with a purpose" helped to create shared meaning among the users of social networking platforms. Two project workshops helped align Triple-C with the research activities of its associate partners, increase the project's visibility, and foster the collaboration with leading international organizations.

Future work will leverage the information management infrastructure, extensive knowledge repository and methodological advances of the Triple-C project. Specifically, we aim to investigate the way climate change issues are communicated between the actors involved, and to the general public at large. The insights from Triple-C will help to contextualize the information gleaned in terms of the interests of the stakeholders in question.

Experiences and values are increasingly expressed and shared via social media, which significantly impacts the formation and evolution of individual and collective values. The Triple-C annotation mechanisms capture this context by enriching information objects with metadata attributes, which allows the inferring of the time and geo-location of a communicative event, and also yield references to previous messages in a thread. Future work should apply the principle of automated annotation to users as well (and not only to the messages that they exchange), clustering users with similar attributes. Contrasting these clusters with categories identified in qualitative interviews and standard demographic segmentations will reveal whether virtual communities are structured along the same dimensions, and how to best accommodate the ad-hoc nature of social media – e.g., how fragmented opinions can be collected, analyzed and translated into concrete policy recommendations.

To further evaluate the validity of game statistics as indicators of environmental attitudes and preferences, we will compare the user-generated ontology in the Climate Quiz game to an expert-generated ontology from climate scientists, NGO members and leading personnel in public administrations, thereby assessing the viability of the "wisdom of the crowd" approach. In extension, we aim to develop subsequent applications of games with a purpose which go beyond measuring knowledge and capture indicators of risk perception or environmental values.

The emphasis of communications assessments needs to shift from measures of *output* to *outcome*. The Triple-C knowledge management infrastructure provides frequency statistics and language characteristics such as positive and negative sentiment. While sentiment is an important and insightful indicator, it does not address some of the fundamental questions of decision makers. Future work will therefore include implicit observations (as compared to explicit data collection methods such as questionnaires) and tailored success measures (as compared to generic metrics from natural language processing, such as sentiment) to measure the attitudes, preferences and acceptance of citizens. While Triple-C predominantly focused on *content production* (i.e., various types of official publications as well as transcripts of stakeholder communication) and a prototype in the tradition of games with a purpose for assessing climate change knowledge, future work should further extend the scope of the analysis by embracing indicators of *content consumption* as well (e.g., search engine data, popular search terms, clickstream data) in order to relate observable behavioral patterns to press releases, campaigns, and external events.

C) Project Details

5 Methodological Considerations

The workflow of the Triple-C project focused on a number of key processes and milestones: (i) the kick-off workshop was instrumental to refine and guide the requirements and specifications of the project, attracted considerable interest among internationally leading researchers, was concluded by a public symposium with invited speakers, and summarized in an official proceedings publications the scope of the Triple-C project and the related views of various stakeholders; (ii) the final version of the project questionnaire, to be served as a stand-alone survey as well as a Facebook application in the tradition of games with a purpose; (iii) significant improvements to the existing content aggregation platform in terms of real-time visualization, transparency of the presented information, and search capabilities; (iv) the launch of the Climate Quiz; (v) the availability of the context-aware editing environment with real-time synchronization to the underlying content repository, and (vi) the final project workshop with the participation of leading international experts.

Incorporating the lessons learnt from the questionnaire survey and the „Climate Quiz", the public release of the *Climate Change Collaboratory* concluded the project. The new platform supports the concurrent editing of documents by multiple users, provides advanced temporal controls to track topical trends and incremental changes of document content, and uses interactive visualizations to reveal the evolution of climate change knowledge. The final workshop and public symposium have increased the visibility of the project, inviting environmental organizations and other stakeholders to actively use the authoring environment and thereby contribute to a common body of knowledge. Additional visualization mechanisms planned for the second half of 2013 will be capable of rendering rapid incremental changes and the profiles of social entities (authors and consumers of digital content).

The public release of the questionnaire as well as the accompanying Facebook application ("Climate Quiz") to capture climate change knowledge have been accomplished successfully. There are ongoing efforts to analyze and interpret the gathered data, as well as the publication of results in established international outlets. Climate Quiz is a step towards leveraging serious games for international social surveys. Despite broad promotional activities and more than 2,000 people who "liked" the initiative, the conversion rate of Facebook visitors to committed Climate Quiz players was low, resulting in a presumably selective sample of environmentally conscious players. Many participants completed only a few game tasks, reflecting a higher task complexity as compared to previous GWAP projects. In the fast-growing market of casual Web games, it is generally hard for environment-related games to become widely accepted.

Comments by users suggest that the game tasks, consisting of pairs of climate change related terms for which an ontological relation has to be specified, were difficult and did not provide enough entertainment value. Future work, therefore, might use paid crowdsourcing platforms such as *CrowdFlower* to pre-process and clean the input data before being fed into the game engine. In contrast, quiz questions were much more fun to play. As the main approach to harness the player's intrinsic motivation, to keep them interested in the game and to encourage them to invite their friends, a higher percentage of quiz questions might be beneficial. Quiz questions should cover numerous topics from climate forecasts over climate policy to private consumption. However, it might be hard to put together a large pool of scientifically valid quiz questions. In addition, the game's point incentive system could be revised. Losing a point for a wrong answer may be a frustrating experience for some players, especially if the opinion of the majority is ambiguous. Bonus points are not a sufficient incentive to complete the online questionnaire; promising additional, advanced game options after the questionnaire is completed could be more attractive. Game tasks that can be solved only in cooperation would strengthen player identification and viral distribution through social networks.

Finally, Climate Quiz is in essence a static game. The game tasks follow a strict format, and do not evolve in terms of complexity or difficulty as the player proceeds in the game. It seems advisable to introduce subtle shifts in the game objectives, in order to more deeply engage players by keeping them on their toes. Enabling players to interactively co-design game tasks could provide such a less-predictable game element.

Beyond these challenges in game design, serious games are a promising avenue in collecting social scientific data. With an attractive game concept, more players may be reached, mitigating the lack of representativeness observed with Climate Quiz. Potential research applications of serious games are manifold, especially regarding longitudinal data from the same individuals. Social scientists could investigate temporal stability of knowledge, the diffusion of knowledge within social networks, and causal relations between factors such as risk perception and knowledge. Longitudinal data could be used even to evaluate causal effects of Web-based intervention techniques like behavior feedback, self-monitoring or self-commitment.

6 Work and Time Plan

- **Kick-Off Workshop, Requirement Analysis**
  - Requirements elicitation with follow-up reporting and refining of the technical plan and use case descriptions – including overview of the state-of-the-art and relevant related research (Y1)
  - System architecture, collaboration environment, and game design (Y1)
  - Strategy for gathering collective intelligence for ontology building (Y1)
  - Proceedings of Kick-Off Workshop (Y1)

- **Managing Climate Change Knowledge**
  - Unstructured Knowledge Management Module
    - Incorporation of Publication Database (Y1)
    - Incorporation of Twitter, Facebook, YouTube and Google+ Feeds (Y2)
  - Social Knowledge Management Module
    - LimeSurvey Questionnaire (Y1)
    - GWAP Engine (Y1)
    - Selection of terms and relations for game tasks (Y1)
    - Pretesting of questionnaire and game formats (Y2)
    - Relation Detection for Ontology Building and Verification (Y2)
  - Structured Knowledge Management Module
    - Dynamic Keyword Graph (Y2)

- **Supporting Stakeholder Communication and Collaboration**
  - Common understanding among the project partners on the functionality of the collaborative editing prototype (Y1)
  - Prototype activation with restricted access to project partners (Y1)
  - Results of usability testing (Y2)
  - Public release of the Climate Change Collaboratory and Climate Quiz (Y2)

- **Analyzing User-Generated Content**
  - Indicator repository (Y2)
  - Analysis and interpretation of the collected data (Y2)
  - Validation of games with a purpose as tools to conduct social surveys (Y2)

- **Data Analysis and Dissemination Activities**
  - Climate Quiz Result Aggregation and Analysis (Y2)
  - Publications (Y1+Y2)
  - Other Dissemination Activities (Y1+2)

- **Final Workshop and Project Conclusion**
  - Expert Workshop and Public Symposium (Y2)
  - Final Report (Y2)

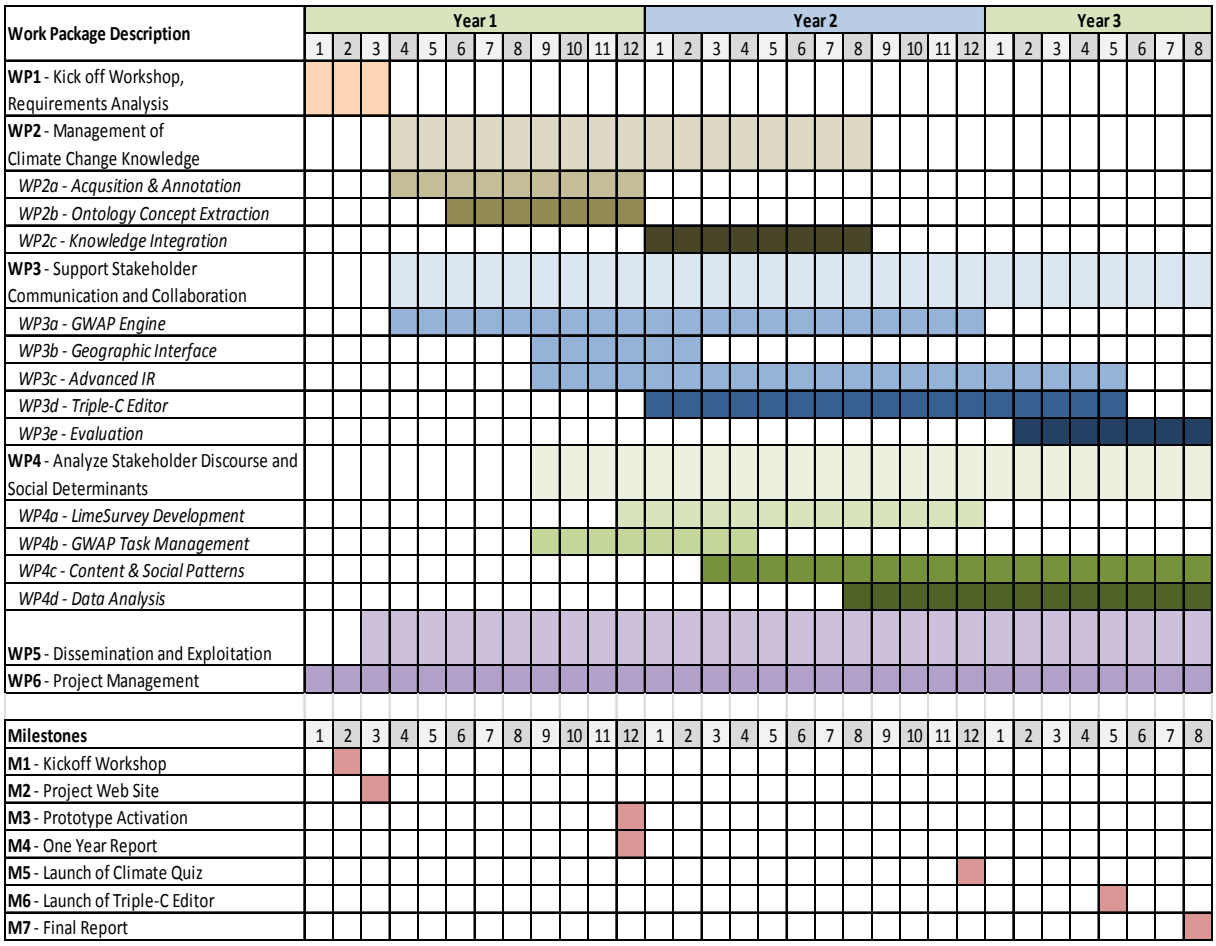

Figure 9. GANTT Chart

7 Publications and Dissemination Activities

Publications

2013

- Seebauer, S. (2013). Measuring climate change knowledge in a social media 'serious game'. To be submitted to the 5th International Conference on Games and Virtual Worlds for Serious Applications, 11-13 September 2011, Bournemouth.
- Scharl, A., Hubmann-Haidvogel, A., Weichselbraun, A., Lang, H.-P. and Sabou, M. (2013). Media Watch on Climate Change – Visual Analytics for Aggregating and Managing Environmental Knowledge from Online Sources. *46th Hawaii International Conference on Systems Sciences (HICSS-46).* Maui, USA. 955-964.

2012

- Aversano-Dearborn, M. and Schauer, T., Eds. (2012). Networking Knowledge – Networking People: New Media for Collective Climate Change Action. Vienna, Austria: Triple-C Consortium. Accessible at: http://www.clubofrome.at/news/newsflash109.html#networking
- Scharl, A., Sabou, M. and Föls, M. (2012). Climate Quiz – A Web Application for Eliciting and Validating Knowledge from Social Networks. *18th Brazilian Symposium on Multimedia and the Web (WebMedia-2012).* G. Bressan and R.M. Silveira. São Paulo, Brazil: ACM. 189-192.
- Wohlgenannt, G., Weichselbraun, A., Scharl, A. and Sabou, M. (2012). "Dynamic Integration of Multiple Evidence Sources for Ontology Learning", *Journal of Information and Data Management,* 3(3): 243-254.
- Scharl, A., Sabou, M., Gindl, S., Rafelsberger, W. and Weichselbraun, A. (2012). Leveraging the Wisdom of the Crowds for the Acquisition of Multilingual Language Resources. *8th International Conference on Language Resources and Evaluation (LREC-2012).* N. Calzolari et al. Instanbul, Turkey: European Language Resources Association: 379-383.
- Piccolo, L.S.G., Scharl, A. and Baranauskas, C. (2012). Design of Eco-Feedback Technology to Motivate Sustainable Behavior: Cultural Aspects in a Brazilian Context. *International Conference on Information Resources Management (IRM-2012).* Vienna, Austria.
- Hubmann-Haidvogel, A., Brasoveanu, A., Scharl, A., Sabou, M. and Gindl, S. (2012). Visualizing Contextual and Dynamic Features of Micropost Streams. *2nd Workshop on Making Sense of Microposts (MSM-2012), 21st International World Wide Web Conference.* M. Rowe et al. Lyon, France: CEUR Proceedings: 34-40.

2011

- Scharl, A., Hubmann-Haidvogel, A., Wohlgenannt, G., Weichselbraun, A., Dickinger, A. (2011): "Scalable Annotation Mechanisms for Digital Content Aggregation and Context-Aware Authoring", *10th Brazilian Symposium on Human Factors in Computer Systems & 5th Latin American Conference on Human-Computer Interaction* (IHC-CLIHC-2011). Porto de Galinhas, Brazil: Brazilian Computing Society: 376-380.
- S. Seebauer, A. Kufleitner: Validation of a Facebook "Game with a purpose" as an Indicator of Climate Change Knowledge. Accepted for presentation at the *12th European Congress of Psychology*, 04-08 July 2011, Istanbul.
- S. Seebauer, A. Kufleitner: Leverage of a Facebook "Game with a Purpose" as a Survey Tool for Climate Change Knowledge. Accepted for presentation at the *9th Biennial Conference on Environmental Psychology*, 26-28 September 2011, Eindhoven.
- A. Scharl, S. Sedlacek, A. Hubmann-Haidvogel, A. Weichselbraun, G. Wohlgenannt, S. Seebauer, A. Kufleitner, T. Schauer and M. Aversano-Dearborn (2011): „Environmental Knowledge Management and Stakeholder Analysis – A Progress Report on the Climate Change Collaboratory", 12th Austrian Climate Day, University of Natural Resources and Applied Life Sciences, 21-22 Sep 2011, Vienna, Austria. V23.

2010

- Scharl, A. and Weichselbraun, A. (2010). "Building a Web-Based Knowledge Repository on Climate Change to Support Environmental Communities", Organizational, Business, and Technological Aspects of the Knowledge Society: 3rd World Summit on the Knowledge Society (WSKS-2010), Proceedings Part II (= CCIS Vol. 112). Eds. M.D. Lytras et al. Heidelberg: Springer. 79-84.
- Aversano-Dearborn, M. and Schauer, T., Eds. (2010). Proceedings of the Climate Change Expert Workshop & Symposium (16 June 2010). Vienna, Austria: Triple-C Consortium. http://www.modul.ac.at/nmt/triple-c/
- Scharl, A. (2010). "Climate Change Communication and Collaboration – Translating Awareness into Collective Action", Proceedings of the Climate Change Expert Workshop & Symposium. M. Aversano-Dearborn and T. Schauer. Vienna, Austria: Triple-C Consortium: 7-9.
- Scharl, A. (2010): "New Media for Climate Change Communication and Collaboration", 11th Austrian Climate Day, University of Natural Resources and Applied Life Sciences, 11-12 March 2010, Vienna, Austria. V28.

Presentations

Date	Activity
Jan-13	Scharl, A.: Presentation of the Triple-C extensions to the visual dashboard of the Media Watch on Climate Change at the 46th Hawaii International Conference on System Sciences (HICSS-2013).
Oct-12	Scharl, A.: Presentation of Project Results at the 18th Brazilian Symposium on Multimedia and the Web and the 27th Brazilian Symposium on Databases (the latter paper was fast-tracked to the *Journal of Information and Data Management*).
Jun-12	Scharl, A.: Introducing the Triple-C Project at a side-event of the United Nations Conference on Sustainable Development (Rio+20).
May-12	Piccolo, L.: Presentation of Project Results on Eco-Feedback Technologies at the International Conference on Information Resources Management (IRM-2012).
May-12	Gindl, S.: Presentation of Project Results on Crowdsourcing at the International Conference on Language Resources & Evaluation.
Apr-12	Hubmann-Haidvogel, A.: Presentation of Triple-C Visualization components at the 2nd Workshop on Making Sense of Microposts, World Wide Web Conference 2012.
Oct-11	Scharl, A.: Invited Keynote on "Creating and Sharing Environmental Information with Collaborative Web Technologies" at the 25th International Conference on Environmental Informatics (EnviroInfo-2012).
Sep-11	Scharl, A. Presentation of Preliminary Project Results at the 12th Austrian Climate Day.
Sep-11	Seebauer, S.: Presentation of Triple-C Project Results at the 9th Biennial Conference on Environmental Psychology.
Jul-11	Seebauer, S.: Presentation of Triple-C Methodology at the 12th European Congress of Psychology.
Jun-11	Scharl, A.: Triple-C Progress Report at the Sustainovation 2011 Conference ("Sustainability as Engine of Innovation").
May-11	Scharl, A.: Live Demonstration of the Context-Aware Authoring Environment developed within the Triple-C Project, New Media Corporate Advisory Board, MODUL University Vienna.
Apr-11	Scharl, A.: Teleconference and Webex Triple-C Demonstration, National Oceanic and Atmospheric Administration (NOAA), Climate Program Office.
Sep-10	Scharl, A.: Presentation of the Triple-C Knowledge Repository at the 3rd World Summit on the Knowledge Society (WSKS-2010).
Jun-10	Climate Change Expert Workshop and Public Symposium, MODUL University (Kick-Off Workshop).
Mar-10	Scharl, A. Presentation of the Triple-C Project at the 11th Austrian Climate Day, Vienna, Austria.