Seven Years of Linking Scottish Schools and Industry with SSTN

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Abstract: The Scottish Science and Technology Network (SSTN) is a major collaboration between Careers Scotland and Scottish industry to promote science and technology via an on-line and integrated learning programme. An initial two-year pilot project has grown considerably and has now been running for over 7 years. The SSTN programme is a web-based application that supports teachers with automatic identification of learning resources, course planning tools, classroom-based delivery (within the 5-14 curriculum) and mentoring support. This paper presents a summary of this project and examples of typical usage scenarios. We present our project findings from this 7 year programme and details of our further development plans. Findings presented include lessons learnt, our best practice guidelines, effective user interface design for learning, integration learning resources and strategies for hiding complexity.

Keywords: Scottish, science, technology, Careers Scotland, SSTN.

1. Background

1.1 Decline in science and technology as a career path

Within Scotland the falling number of pupils that are adopting science and technology as a career path has become a significant political and social concern. Over the past few years there has been an on-going decline in the number of pupils taking both science and technology based subjects at school and then later choosing to study these areas in higher education. This decline has been particularly pronounced for girls studying these subjects.

The future economic implications of this decline for Scotland has led the Scottish Executive to make the promotion of science – and in particular technology – a key underpinning objective of their educational activity programmes. As the principle agency in Scotland providing career education, information and guidance – Careers Scotland – was directed to address this decline. As part of this remit this project has been developed in partnership with Scottish industry.

1.2 Aim and objectives of this project

The aim of this project is to promote the awareness of science and technology and promote these areas as attractive career paths for young people. Additionally, the objectives of this programme are to:

- Promote science and technology in schools
- Increase adoption of science and technology as a career path
- Enhance the awareness of science issues in young adults (such as global warming)
- Encourage more women to take science and technology as a career path
- Promote the active participation of Scottish industry in the classroom
- Facilitate the use of Information Technology (IT) in lesson planning and delivery
- Directly support the national 5-14 curriculum
- Encourage industrial participation in schools
- Integrate with other on-going educational programmes
- Establish an industry based network of mentors, able to provide assistance to pupils and teachers within Scottish schools on issues relating to science and technology

2. Scottish science and technology network

2.1 Overview

The Scottish Science and Technology Network (SSTN) is a major collaboration between Careers Scotland (Careers Scotland 2007) and Scottish industry to promote science and technology via an on-line system. An

initial two-year pilot project (Stevenson 2003) based in the North East region of Scotland has grown considerably and has now been running at a national level for over 7 years.

The SSTN project links a network of participating schools within Scotland and spans the full spectrum of the 5-14 curriculum. This programme uses a web-based application for supporting learners (aged 5-14), teachers, mentors and administrators and includes an extensive library of Reusable Learning Objects (RLO) – so-called "resources" within SSTN – which has either been specifically developed for this project to address "gaps" in the curriculum or are integrated from external third parties.

The SSTN programme supports teachers with automatic identification of learning resources, course planning tools, classroom-based delivery (within the 5-14 curriculum) and mentoring support. The framework provides a unique resource allocation strategy to deliver content dynamically within the classroom environment and closely integrates with other Careers Scotland programmes such as "Blast Off to Science" (part of the Scottish Space School which is delivered in coordination with NASA) as well as other third party resources.

Additionally, SSTN has previously establishment of an industry-based network of mentors, able to provide assistance to pupils and teachers within Scottish schools on issues relating to science and technology.

2.2 Current project status

As of October 2007 there are 7 major local authority regions in Scotland participating in SSTN and these are spanning the full spectrum of the 5-14 curriculum. The core service is funded by Careers Scotland with regional government contributing to their own local activities and the overall cost of delivering the programme.

Each region of the seven regions has an 'administrator' to oversee the on-line and off-line delivery of the programme within their area and a central team (based at Careers Scotland in Glasgow) has the remit of overall direction and delivery. There is an on-going programme of teacher training and development around SSTN and its resources within each region.

This programme has been used as a gateway for other Careers Scotland project and programmes such as "Space Explorers Scotland" and "Blastoff to Science" – see below. This approach has lead to an increased awareness of each programme of work.

3. System architecture

3.1 Overview

The SSTN is a web-based system whose core process allows teachers to outline a profile of a lesson plan they wish to deliver. The teachers' requirements are expressed using the national (standardised) 5-14 framework (used within Scotland) and are aligned to the individual pupils learning needs. Once the requirements have been expressed – using a simple-to-use wizard based system – the SSTN system then automatically identifies a collection of educational resources (so-called "Reusable Learning Objects – RLO) that fulfil the specified profile.

The identified learning objects can then be delivered on-line to the pupils either individually or in groups with minimal supervision. The teacher has the option to filter (add, remove or change) any of the automatically identified resources to meet their individual teaching needs.

Based around this core process a number of additional processes have been built to add value to the teachers, pupils and other SSTN users. These include:

- **Industry-based Mentor Interactions**. The system has the capability for classroom based pupils to "ask a question" of an industry based mentor (in a secure managed manner). The mentor is the notified of this question by e-mail and they can then answer on-line. The record of such dialogues is kept within SSTN and in turn becomes a resource that can be referenced and searched in the future by other teachers and mentors.
- **Lesson Planning Tools**. Using the lesson planning tools teachers can quickly and easily create their lesson plans on-line and then download them for use in either Microsoft Word or Adobe Acrobat formats. By downloading such documents in an editable format teachers can customised them off-line for their own individual needs.

- **Administration Support**. Within SSTN there is the capability to allow regional educational managers to view (via the web) activities within each classroom. This allows the to quickly access in real-time the current situation within each school in their region.
- **On-Line Forums**. These are managed and monitored discussion areas where different communities can hold discussion areas (teachers, mentors, administrators, etc.) This has been used previously to build community based upon geographical location, special events and common areas of interest.

A key objective in the system design was that this process should be quick and easy to use for both the teachers and the pupils alike. In the following sections we outline the key features of the system and then describe the typical usage scenarios.

3.2 Key features

There are a number of novel and key features that have been developed and deployed within the SSTN programme. These include:

- **Architectural Design**. This application's architecture ensures that it can be readily scaled (capable of being run simultaneously on multiple servers – to provide load balancing and redundancy) and being written in the Java™ programming language it is portable between multiple and mixed environments.
- **Knowledge Representation**. The pilot programme (Stevenson 2003) had previously identified that a novel architecture and representation would be required to meet both the short and the long-term needs of the project. The knowledge representation architecture selected uses a semantic network representation (Quillian 1966) similar in style to Resource Description Framework (RDF) (RDF 2003). This provides a flexible representation, interoperability with other semantic web initiatives and integration with other related areas (such as e-learning standards). However, wherever possible, the complexity of the presentation technology is hidden from the users via a simple-to-use interface.
- **Resources Allocation Strategy**. As described elsewhere (Whittington 2003) the resource allocation strategy provides SSTN with the capability to dynamically encompass and utilize new learning resources – quickly and simply.
- **Strict Alignment with National Curriculum Guidelines**. The project was designed 'ground-up' to comply with the latest national curriculum guidelines and therefore meeting national targets. By being capable of supporting multiple standardized curriculum frameworks the system can be regionalized and is capable of handling future changes to the curriculum.
- **Ease of Access and Use**. The deployment of this application is simple and low cost as it can be readily accessed from any standard compliant web browser. The user interface has a simple "flat" layout and uses both wizards and "forms" to provide users with a structured framework for accessing, creating, editing and managing information and workflows.
- **Use of Industrial Mentors**. The way mentors have been deployed in an asynchronous manner in this project has proved to be effective and powerful in supporting continuous project-based activities. This has enabled the latest techniques used in industry to be brought into the classroom and has added significantly to the value of project work. This approach seeks engage pupils with realistic practical industrial situations and applications rather using the "classic" academic study approach alone.
- **Security and Privacy**. A considerable effort has been made within SSTN to ensure that the necessary checks and balances are in place to allow an effective level of security and privacy to be maintained.
- **Real-World Application**. The SSTN is a real-world application and is being actively used and developed with real mentors, teachers and schools.
- **Distributed Web-based Management**. The application is entirely web-based with access to all aspects of its management (from the administrators downwards) being done via a web-based interface.
- **Learning Resource Library**. An extensive library of resources (ROL) has been collected which is directly mapped to the (Scottish) 5-14 curriculum.

3.3 User Interface

Each user role in the system (teacher, mentor, pupil, etc.) has a unique visual design and layout of the functionality based upon a familiar "portal" style (which was far less common when the project was initially started). The user interface has been specifically designed to meet the evolving expectations of a user community. The interface has evolved through several different visual designs as new functionality was integrated during the course of the project. For example, Figure 2 - Tabbed Screen of 'Mentor' Desktop illustrates the layout before additions to the functionality and the corporate re-banding of Careers Scotland and Figure 2 - Tabbed Screen of 'Mentor' Desktop after these changes (not the new tabbed interface to accommodate additional functionality whilst retaining the simple "see everything" 'direct layout' approach).

Within this interface we have chosen to use 'direct layout' (where all the options and/or fields are displayed on-screen) or 'wizard-based' approach. We selected this approach based upon the objective that the users should be able see all the options available to them without having to interact with visual elements (such as menus) to see what options were available. This approach prevents the users from needing to "click to see what is available" and forgetting the location of different options. This approach both reduces training time and makes the user interface appear "simpler" to users whilst still offering them the same level of functionality.

An example of a pupil screen is shown in Figure 3 - Sample Pupil Desktop. The teacher can optional select one of a number of themes to style the pupils' screen to ensure that it is suitable and engaging for the age range of the pupils.

Help and support for users was also supplemented by the use of 'screencasts' that illustrated common tasks that users commonly performed (this also provides a valuable resource for 'bootstrapping' administrators and support staff).

More recently (Summer 2007) SSTN software has been updated to incorporate the latest web standards and to increase in compatibility with new mobile devices such as Apple's iTouch and iPhone unit, which will become available in the UK during the last quarter of 2007.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 1: Classic screen image of 'Mentor' desktop
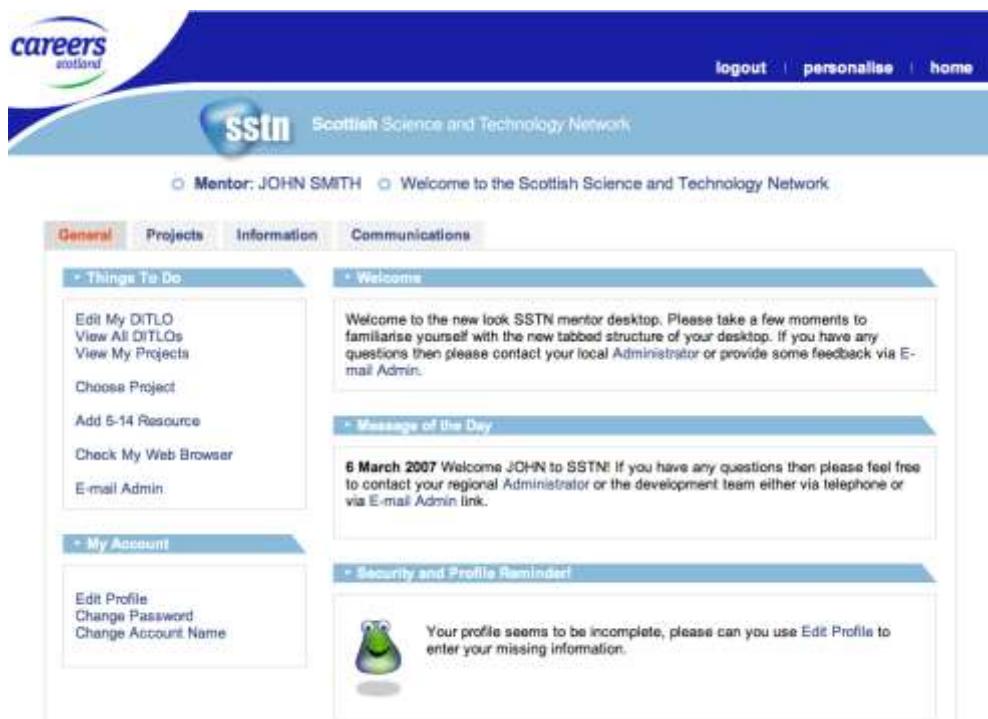
Figure 2: Tabbed screen of 'Mentor' desktop

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Figure 3: Sample pupil desktop

4. Usage scenarios

There are a number of different types of users who participate in the SSTN programme. Some of the SSTN roles include:

- **Teachers** – These are classroom-based teachers who use SSTN to plan and create on-line programmes of work and then later – during classroom time – use SSTN to deliver customised content to their classes.
- **Mentors** – These are industrial based users who provide on-line support for specific topic areas and can interact with classroom-based pupils via the SSTN web site.

- **Pupils** – These are children or young adults who are classroom (or home) based learners and who login to access specific content and resources to meet their learning objectives.

The following sections provide brief scenario descriptions of how the SSTN is being used. The participants in this example scenario are (a) a classroom-based teacher within a secondary school (ages 12-14 years old) (b) pupils ("learners") studying under this teacher and (c) an industrial mentor (based in an external company).

4.1 Teacher lesson planning scenario

Typically each teacher would receive an induction programme delivered as group by their regional administrator. This starts the progress of building a community around the SSTN as the teachers can meet other teachers in their region using the tool and their regional administrator, which makes subsequent on-line communications with individuals easier and more effective.

Once the teacher returns to the classroom, after receiving their initial training, they identify suitable groups of pupils to work with. The teacher would login with their personal account details and enter the profile of the lesson that they would wish to create, using the on-line tools, and the system would identify suitable learning resources and activities for each of the learners or learners groups (where the learners work together and are at the same level of attainment). The teacher would then create accounts for these individuals or groups and then these accounts are immediately enabled for use within the classroom. Each account implicitly has an associated "project" which is the focus of study – for example, "Solids, Liquids and Gases" or "Energy and Forces" are projects that have been undertaken. These projects are automatically linked to the local education authority's programme of work and to the national 5-14 curriculum standards.

For example, in Figure 4 – A Sample Teacher Project Screen is shown that illustrates both summary of the group structure (full hierarchical information can also be displayed if required by the viewer), the groups associated with the group and the resources (both "standard" ones – suggested by SSTN – and the ones added in a customized why by the teacher). Notice the extensive use of automatically hypertext linking of all the elements of the system, which is key to making the system easy to use.

Figure 4: A sample teacher project screen

4.2 Individual and group learner (pupil) scenarios

In the classroom the learners use their individual or group accounts to access the SSTN service via a standard web browser. When they enter the SSTN each of the learners is provided with a unique combination of learning resources, which have been established by the teacher (see previous section). These resources will range from highly specific learning resources (matching as closely as possible the learning needs of the learner at their current level of attainment) to more general resources relating to the

project being studied. Learners are free to explore these resources or may be guided by their teacher depending upon the learning objectives. Additionally, under the supervision of teachers, learners can initiate either "Question and Answer" or "free form" dialogues with industry mentors who have been assigned to their project.

4.3 Mentoring scenario

The industrial mentors can be automatically or manually identified ("matched") against each of the project types. Once the match has been made the learners (or the teacher) may engage their mentor by sending a message or a question about the project specifically or about a general (related) topic. The SSTN system does not facilitate direct contact (such as e-mail or chat between learners and mentors) but mediates the conversation for reasons of security, privacy and confidentiality. Any "Question and Answer" dialogues between the mentors can then be used to supplement the Frequently Asked Questions (FAQ) or provide a record for future reference and use by other (non-pupil) users. Mentors are provided with training and promote investigative training. The subsequent school visits by Mentors (where possible) have also been very popular with teachers and pupils alike.

5. Integration with external learning resources

5.1 Overview

During the course of this project a library of specifically authored resources have been commissioned to address specific parts of the supported curriculum where suitable existing resources could not be found. Additionally, sponsors have donated other resources, such as BP's ETAP resource to our library.

However, a significant number of resources have been located on the Internet and been added to our resource library. We classified these resources into three categories, namely,

- **Tightly Coupled Content**. This type of resource was specifically designed to work with SSTN alone and it was tightly associated with SSTN and could leverage its infrastructure. Full meta-data about the resource is available to use by SSTN.
- **Loosely Couple Content**. This type of resource could be used in a "standalone" mode (without reference to SSTN) but its constituent components could also be referenced as individual resources with SSTN because the meta-data is available.
- **Reference Content**. This type of external resource of which SSTN has no control or authority. Often these are resources that lack the necessary meta-data and are authored and maintained by a third party.

The process of adding an external (third party) resource involves:

1. **Identification**. The resource is submitted either by an existing community user (such as a teacher or mentor) or a third party resource author/provider.
2. **Review**. A qualified user (for example a seconded teacher) then reviews the resource to ensure that it meets this project's acceptance criteria (such as production values, quality and education value).
3. **Classification**. The resource is then classified for use in the system and the resource is announced to community users who have expressed an interest in this category of resource.

There are a number of issues associated with using resources that are hosted externally (by a third party) including:

- **Resource Integrity and Quality**. Once the resource has been reviewed, classified and accepted it is important that if the resource changes that this is immediately notified and the changes can be reviewed to ensure that the resource is still relevant and appropriate.
- **Resource Availability**. As the resource is hosted externally SSTN has no control over the availability or quality of the link ("bandwidth") to the resource. If the resource fails whilst it is being used during a classroom scenario this is problematic for the users and teacher alike. By monitoring the availability of the resource automatically we can become aware of quality and availability of individual resources.

In the following sections we illustrate how these issues were addressed for tightly, loosely and referenced integrated content.

5.2 Resource Description Framework

5.2.1 Tightly Integrated Content – "Blast Off To Science"

To promote space-based science and technology Careers Scotland has run a programme of teacher events and school visits with NASA astronauts (Space Explorers 2007). As a prelude to these events schools are required to learn more about the various space programmes and the visiting astronauts. This is done via the SSTN and by use of the (tightly integrated) 'Blast Off To Science' web site. This web site features a (teacher developed) activity plan for pupils which includes:

1. **Mission Box**. In this section pupils are set the task of creating their own mission box and investigating what the content might be for "their" mission.

2. **Mission Patch**. In this section the pupils are set the activity of creating a mission patch that involves directed research into the history and meaning of existing NASA mission patches.

3. **Quiz**. This is an on-line assessment that evaluates the information that has been delivered in the previous two stages. At the end of this assessment they are issued with their unique space passport.

4. **Space Passport**. Once the pupil has successfully completed the previous stages of the programme the pupil can print a certificate with their name (and unique reference number) to "allow them" to attend the event.

The main navigation screen from the 'Blast Off To Science' is shown in Figure 5 – Blast Off To Science Navigation Screen. This programme of work has been integrated in two different ways into SSTN either as a single discrete element of course work or as three individual elements that the teacher can use in a standalone manner.
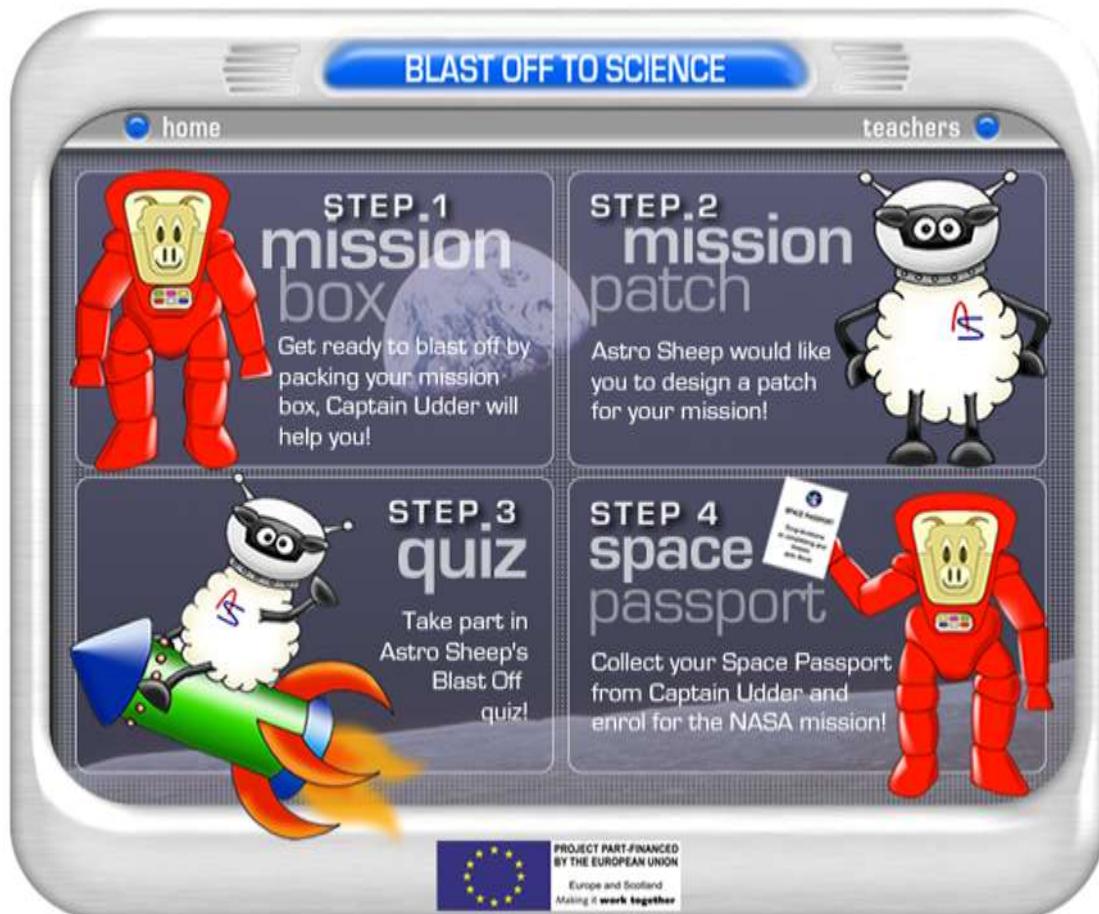

Figure 5: Blast off to science navigation screen

5.3 Closely Coupled Integration – "Space Explorers Scotland"

As part of the coordinated activities with the Association for Space Explorers Congress event held in Scotland 2007 (Space Explorers 2007) a web site was developed (Space Explorers 2007b) which delivers four 40-minute lessons that provide an on-line introduction to space science and technology. Each lesson has two versions, one for the **S1-S3** and one for **S4-S6** ability ranges. The pupils will access the web site and carry out incremental explorative research, building their own on-line research portfolio, before printing out their research at the end of the lesson as a mind-map, timeline or in a notebook format. Alternatively, they can save their portfolio on-line for later use and extend their research portfolio as they complete further lessons. An example screen from the current of this web site is shown in Figure 6: Topic Selection Screen From The Space Explorers Scotland Web Site.
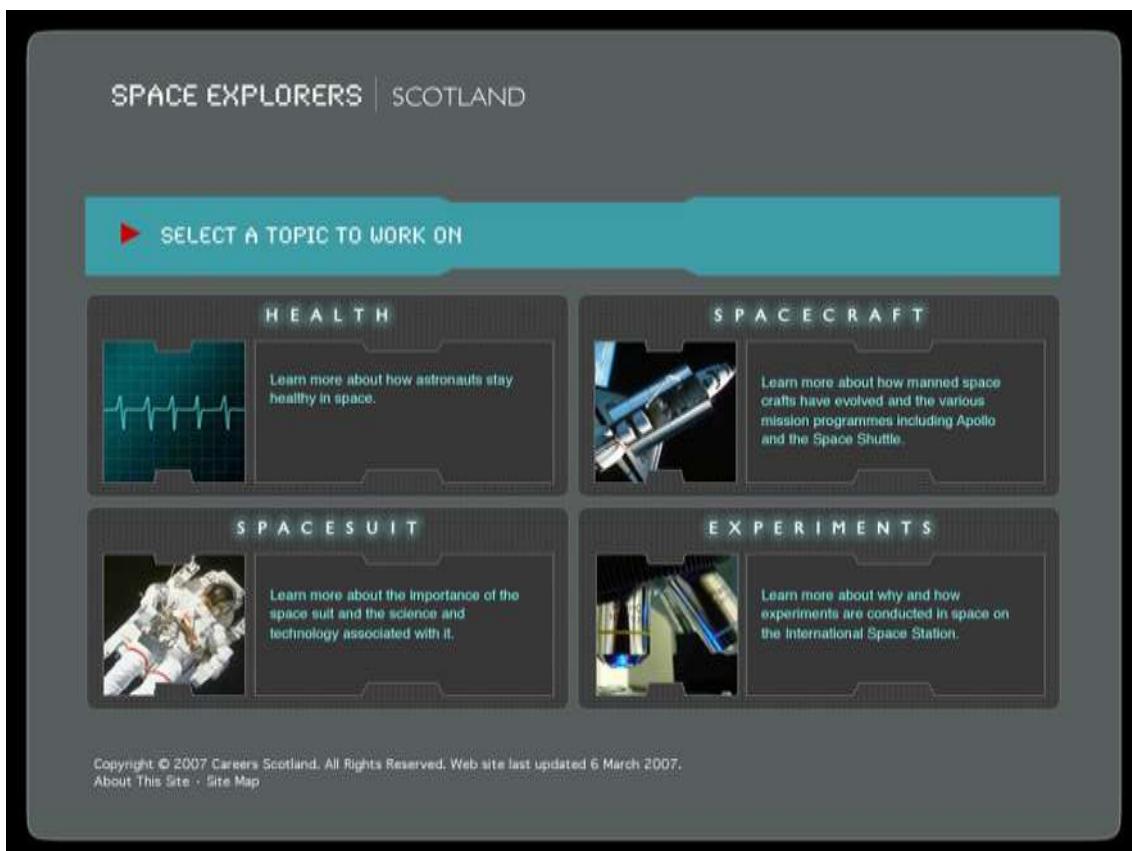

Figure 6: Topic Selection Screen from The Space Explorers Scotland Web Site

The learning resources created for this web site are closely integrated but as they are described via RDF they are readily integrated as standalone resources for use within the SSTN system. In this way the learning content and resources can be readily repurposed to use within a different context as required by the individual needs of teachers (for their pupils).

6. Discussion of Challenges and Lessons Learnt

6.1 Overview

In this project we have addressed a number of important issues, some of which were anticipated and others that evolved from our experiences in using SSTN with an active user community. In the following sections we have highlighted a number of these areas, with an outline description and discussions on our experiences and solutions.

6.2 Evolution of Data and Knowledge Structures

The scope and context of this project was sufficiently well understood to realize that data and the representations initially implemented would need to be continually updated as the system evolved. It was appreciated that there would be an on going challenge of managing the evolution of not only the data but the

representation of the data. Backward compatibility and evolution were necessary, as the system could not be taken off-line for upgrades as the system is in constant use.

As the project was developed and deployed it was very important to be able to use an incremental approach to extending the scope of the functionality. This was particularly important, as feedback from users was a key factor in meeting the community's needs. A "one-size fits all" approach would not have been acceptable for this project.

There was a strong desire to integrate with other national and international projects. The interoperability issues with integrating either fully or partially were of interest to this project. Wherever possible it was desirable to adopt and use existing e-learning and metadata standards. This application has developed and deployed 'virtual sub-networks' to provide a mechanism for managing change and providing backward compatibility with a changing code base (Whittington 2003). This is a generic technique that can also be applied in other application scenarios.

The project has demonstrated that the semantic network approach can be highly successfully and has shown that this approach is scaleable for future large-scale, real-time scenarios.

6.3 Hiding Complexity with Simple User Interfaces

The users are drawn from various age groups (for example, primary and secondary school pupils) and different skills levels (from industrial experts to primary school pupils). All issues of complexity and representation must be hidden from the end-users.

6.4 Security and Privacy

Within the UK there has been a growing need to ensure the on-line security and privacy of users and in particular those of children and young adults. Our user community can be both inexperienced online users and unaware of the potential threats presented by other children and adults online. To address this, the SSTN programme has deployed a number of safeguards to ensure the security and privacy of its users. These have included:

- **Security Checks on All Participating Adults**. All adults accessing the system are subject to Disclosure Scotland (Disclosure Scotland 2003) checks for their suitability for working with young learners.
- **IT Infrastructure**. A range of standard IT security measures have been implemented to ensure the integrity of the SSTN system. These include user visible elements, such as using SSL communications, as well 'stealth' techniques to monitor and record users activity.
- **Active Content Monitoring**. The content of the system is actively monitored – both using automated tools and by visual inspection by the administrators. As each of the users is tracked via the login (including IP tracking and session tracking) any inappropriate activity is quickly identified and reported to the school and teachers.
- **Parental Controls**. Initially in some regions parents were specially ask to sign legal disclaimer forms before their children could use SSTN. Latterly, this has been replaced by an overarching educational region disclaimer that includes SSTN programme as well as other on-line services that are used in schools.

6.5 "Busy" Mentors

Mentors are industrially based volunteers who have busy schedules and SSTN can sometimes be forgotten in the hectic day-to-day business life. The SSTN system continues to provide e-mail based notification but it is also actively evaluating using mobile phone messaging (both SMS and MMS) and instant messaging to provide more immediate notification, information and updates to mentors, teachers and even learners (such as school pupils). It is anticipated that the immediacy of mobile phones will enhance the use of the SSTN and match well with the culture of younger SSTN users.

6.6 Coordinated On-Line and Off-Line Activities

We have found that to build a successful community it is important to have a programme of both on-line and off-line activities. The use of such events – where community members can meet face-to-face – have been particular successfully and this has been adopted in other programmes (such as the teacher induction events and teachers' "sleep-over" events at science centres). By integrating these activities with the

teachers' Continuing Personal Development (CPD) programmes it enhances their ICT skills and confidence to deliver the programme whilst still being considered part of their on-going CPD programmes.

In the future we plan to hold national on-line events – such as "Weather Watch Scotland" (Weather 2007) – that involve an integration of off-line activities (measuring temperature, cloud cover, etc) that are then recorded on-line and viewed on 2D and 3D maps of Scotland.

Careers Scotland is also currently (4Q2007) developing a national showcase for science activities in Scotland (Science 2007) which extends this approach to encompass national and regional activities.

We have also found that building "brands" around each of the Careers Scotland products (such as "Blast Off to Science" – "Astro Sheep" – see Figure 5 – Blast Off To Science Navigation Screen) have been highly effective and can be applied to both off-line (posters, event branding, handouts, worksheets, etc.) as well as on-line. This has enhanced the product recognition and awareness in the educational community.

7. Future directions

There are a number of key areas that we are currently exploring for future integration into future projects. These include:

- **Integration of High-Level Functional Content Blocks**. At the present time we have successfully integrated content from external and in-house resources within the unified framework of SSTN. We are now exploring how we can also integrate functional blocks into SSTN from external resources. This would allow us to leverage third party functionality whilst retaining the ease of use of the SSTN user interface.
- **Remote Web Service Integration**. We are exploring a number of options such as Web Services for Remote Portals (WSRP) approach as well as AJAX-based APIs. At this time (1Q2007) we are the early stages of evaluating these approaches.
- **Mentoring**. We have found that mentors often need considerable support to become familiar with modern education language and practices. Often they are unsure of the language used by teachers, aspects of the modern curriculum and the way educationists discuss topics (can be initially inaccessible to the mentors). We are seeking better ways to provide the necessary training support to overcome this issue.
- **Communication and Notification**. Reliance on using solely e-mail based notification can be ineffective where there is no culture of reading e-mails each day. Using such an approach alone can be problematic and cannot be relied upon with disparate user communities. Both direct contact (telephone or mobile phones) and 'social' events are vital in building community in such circumstances. We are interested in using various forms of 'instant messaging' technologies to enhance the delivery of this programme.

8. In Conclusion

Over the course of this programme we have developed and deployed a national e-learning system to promote science and technology within Scottish education. The primary aim of this project is to encourage young adults to choose careers in Science and Technology as a valid and valuable career path.

This paper has outlined our approach and some of the key lessons learned from this programme. This project has a national user-base and has demonstrated this approach as a valuable and cost effective mechanism for promoting science and technology to young adults. By leveraging the value of other related projects – such as "Blast Off to Science" and "Space Explorers Scotland" – there has been a significant benefit to all of the participating projects.

We have demonstrated its value as a signposting portal to leverage third party educational resources in the classroom. Subsequent and related projects have benefited from the experiences gained in this programme.

We have demonstrated the practicality and value of provide fully and semi-automated assistance for lesson planning and reporting in the modern Scottish classroom.

Acknowledgements

Further Information

Further information about the SSTN project is available from our main publicity web site at http://www.sstn.co.uk/ Participant in the SSTN project is open to all schools in Scotland. Please contact your regional administrator for further details.

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