



## Empowering teachers:

Summary of qualitative evaluation of  
the *Navigation Through the Ages*  
Massive Open Online Course via  
participant observation.

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*“No matter how old our students are, the subject of navigation is fascinating and lends itself to a variety of practical activities that can be inspiring and engaging. We are all travellers in time and space...” (Teacher, Italy)*

# Contents

<b>1</b>	<b>Introduction</b>	<b>4</b>
1.1	Course structure and content	6
1.2	Ethical considerations	7
<b>2</b>	<b>Data collection and analysis</b>	<b>8</b>
2.1	Data	9
2.2	Analysis	9
2.3	Participants	10
<b>3</b>	<b>Summary of results</b>	<b>12</b>
3.1	Learning outcomes	12
3.1.1	<i>Enjoyment, inspiration and creativity</i>	13
3.1.2	<i>Values and attitudes</i>	14
3.1.3	<i>Knowledge and understanding</i>	16
3.1.4	<i>Do: Action, behaviour and progression</i>	19
3.1.5	<i>Skills: space science, teaching and learning, ICT</i>	22
3.2	Educator segmentation	23
3.3	Contrary evidence, and limitations	25
<b>4</b>	<b>Conclusions</b>	<b>26</b>
<b>5</b>	<b>References</b>	<b>29</b>
<b>6</b>	<b>Appendices</b>	<b>29</b>
	Annexe 1. Email sent to Navigation Through the Ages MOOC participants	30
	Annexe 2. Resources and Quick Access Data Map	32



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## List of Tables

Table 1: Map of intended outcomes for the Navigation Through the Ages MOOC.....	5
Table 2: Sample of teaching plans. These are referenced throughout this section. ....	13
Table 3: Summary of achieved outcomes .....	26

## List of Figures

Figure 1: Summary of participation opportunities which are also data sources. ....	6
Figure 2: Global participation map. ....	10
Figure 3: Enlarged map of regions showing highest density of participants.....	11
Figure 4: Generic group profile of participants' professional backgrounds.....	11
Figure 5: Bricolage of positive statements and inspired photographs.....	13
Figure 6: Indications of teachers' confidence to inspire students. ....	14
Figure 7: Example of cumulating resources to reuse in classroom activities.....	15
Figure 8: Diversity of ideas on topics that could be taught using the navigation theme. ...	16
Figure 9: Collection of posts on the course knowledge content. ....	17
Figure 10: Teachmeet presentation on using recycled material to construct a quadrant..	18
Figure 11: Teaching Plan reflecting key MOOC themes .....	18
Figure 12: Indicators that children and young people are beneficiaries.....	21
Figure 13: Career link posted in the MOOC Facebook group and on Twitter.....	22
Figure 14: Examples of teachers reflecting on their practice.....	22
Figure 15 : Examples of educators affiliated to national astronomy institutions.....	24

*The Space Awareness Project team at UCL are grateful to the all the educators that took part in the Navigation Through the Ages MOOC. Thank you especially to those that contributed by talking to the researcher. Their generosity made the investigation possible.*

# 1 Introduction

This report complements the [questionnaire-based evaluation](#) of the Massive Open Online Course (MOOC) *Navigation Through the Ages*. The aim in this report is to draw on qualitative data to build a rich picture of how the course engaged educators and how this in turn is translated into practice and student engagement.

To experience the course as a participant, a single researcher enrolled on *Navigation Through the Ages* as a participant observer (the process is described in more detail in section 2). Like the other MOOCs, *Navigation Through the Ages* started with an introduction followed by a set of paced modules (the course structure and content is described in section 1.1). The course introduction presented the participants with an overview of ICT tools and opportunities for participation and interaction with each other. For the researcher these were also opportunities for gathering data, and to follow up these public interactions with conversations via email and online chat (data sources are described in more detail in section 0). From these activities some of the richest qualitative data came from these sources: participant posts and learning diaries published in Padlet<sup>1</sup>; lesson plans published in Learning Designer<sup>2</sup>; recorded webinars; the MOOC Facebook group and small group email exchanges.

The MOOC course *Navigation Through the Ages* is aligned with specific learning objectives based on the Space Awareness Generic Outcomes (GO's). Table 1 provides a map of the GO's for the MOOC *Navigation Through the Ages* (as identified by the course leader). In addition, specific space science knowledge outcomes for the *Navigation Through the Ages* course were:

- The history of navigation
- The importance of measuring space and time through the ages
- Celestial navigation concepts
- Celestial objects and instruments
- Europe's current Galileo Programme

As a shorthand the five GO categories are denoted by themes – **feel, value, understand, do** and **skills**. The themes **feel** and **value**, are major priorities in this MOOC. Table 1 shows the generic outcomes targeting educators and students. However, there were no students enrolled on the course. One of the motivations for the qualitative evaluation was to understand how teachers' learning translated into teaching in practice, and to seek out proxy indicators of effects on students' learning. To illustrate this Table 1 also includes some of the questions that guided the researcher in what to look for.

At the end of this report the GO map is used to summarise findings from the qualitative evaluation.

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<sup>1</sup> [Padlet](#) a digital scrapbook i.e. a web based means of collecting ideas and resources and sharing online


<sup>2</sup> [The Learning Designer](#) is a set of tools that teachers used to design and share lesson plans.

<b>Navigation Through the Ages Intended Outcomes Mapped to the Space Awareness Generic Outcomes</b>	<b>Educators</b>	<b>Students</b>	
<b>Feel <i>Enjoyment, inspiration and creativity</i> = MAJOR PRIORITY CATEGORY</b>			
Enjoy learning / teaching about space	X	X	In what context are feelings expressed in words and images? What narrative are associated with positive /negative/other kinds of enjoyment? How is creativity shown?
Feel confident teaching space topics	X		
Feel inspired by space science	X	X	
Feel positive about space science		X	
Aspire to space science careers		X	
<b>Value <i>Values and attitudes</i> = MAJOR PRIORITY CATEGORY</b>			
Value the diverse contributions of many different cultures to space science	X	X	What motivate the teacher to take part in the MOOC? What evidence is there that cultural diversity is valued? Are contributions of men and women to space science recognised? How is school science linked to the MOOC.
Value the contributions made by both women and men to space science	X	X	
Appreciate that space science contributes to everyday life	X	X	
Appreciate that people who work in space science are real people	X	X	
<b>Understand <i>Knowledge and understanding</i></b>			
Highlights of space science (Navigation through the Ages)	X	X	Where is the evidence that teachers feel more confident about the topics? What disciplines are represented? What content is used, when, where and how? What content/ ideas are applied, adapted, evolved, developed or discarded? Is there evidence that this is impacting on students' engagement?
The impact of space science on society and everyday life	X	X	
Space science can be used for teaching in many disciplines including cross-disciplinary contexts and non-science subjects	X		
Space science career opportunities are diverse, rewarding and highly accessible (particularly to girls and ethnic minorities)	X	X	
Career opportunities in space science and technology at all levels	X		
Relevant pathways to these career opportunities	X	X	
<b>Do <i>Action, behaviour and progression</i></b>			
Access and use Space Awareness activities confidently	X		Where is the evidence that teachers are using the MOOC content and activities? Do teachers create new content? Are there opportunities for sharing good practice? What other Space Awareness Activities have teachers been involved with?
Create own content and additional activities on the same or related topics	X		
Want to learn more about space science		X	
Choose or consider choosing, or encourage others, to study and pursue careers in space science and engineering or science and engineering more widely, especially girls and ethnic minorities	X	X	
Share their understanding of space science and technology with learners, peers, family and/or their community	X	X	
<b>Skills</b>			
Develop inquiry-base skills for teaching/learning about space science	X	X	Is there evidence that demonstrate skills development e.g. ICT, inclusive teaching, inquiry design?
Learn how to use IT to teach/learn about space science	X	X	
Learn how to be more inclusive while teaching, particularly for girls and minorities	X		

**Table 1: Map of intended outcomes for the Navigation Through the Ages MOOC.**

## 1.1 Course structure and content

Each MOOC, including *Navigation Through the Ages*, started with a course introduction. This orientated the participants with information about the structure and content of the modules that make up the course. The introduction covered the logistics including scheduled activities, duration and workload, code of conduct, information about assessment and certification, and how to get help. Importantly the course cohort was introduced to the tools used for participation, and the participation opportunities. The participation opportunities and associated tools were recognised by the participant observer as primary sources of quality data. This is illustrated in Figure 1 and described in more detail in section 2.

 Course introduction	Participation Opportunities
✓ A. Course timeline	<b>Course timeline</b> -Times of live events including webinars and teachmeet. -Each module ends with a question for the participants to share their reflections. Generally Padlet is used for this.
✓ B. Who you will be working with	<b>Who you will be working with</b> -Infogram – snapshot of participants backgrounds. -Zeemap – participants share their location and preferred name.
✓ C. Your Learning Diary	<b>Learning Diary (LD)</b> Participants are invited to introduce themselves in Padlet and share their LD. Other optional tools for LD are Glogster, Dipity, Google Documents and Tackk.
✓ D. Introducing the Learning Designer	
✓ E. Code of Conduct	
✓ F. Course Introduction Quiz	<b>Assessment</b> Participants are introduced to a learning design tool called Learning Designer, how to create lessons plans and give peer feedback to others on their plan.

**Figure 1: Summary of participation opportunities which are also data sources.**

After the introduction week, the MOOC course *Navigation Through the Ages* was organised into 4 modules:

- Module 1: Introduction to Navigation through the Ages
- Module 2: The history of navigations
- Module 3: Navigation tools and terms
- Module 4: The European Global Navigation Satellite System

The modules were broadly aligned to the knowledge outcomes for this MOOC course.

Each module consisted of:

1. **Content** resources: including videos and reading, practical examples of adapting the content to teach specific topic, interviews with teachers, classroom footage of young people working with the resources, lectures on inquiry based learning and managing diversity in the classroom and interviews with experts about their career in space science.
2. **Software tools** and opportunities to and see how these are used for teaching and learning.
3. **Distributed activities** for example questions to stimulate online discussion and networking. In addition, each participant was encouraged to develop a Learning Diary.
4. **Synchronous activities**, including a recorded expert WEBINAR with Cecilia Scorza, on Intercultural science; and a recorded 'teachmeet'<sup>3</sup> in which teachers were invited to present their work on adapting the MOOC resources with a focus on innovation in the school and classroom.
5. **Assessment** including a quiz at the end of module 1, 2 and 3; and a final peer reviewed assessment which was a lesson plan.

To receive the digital badges and certificate at the end of the course the participant had to score at least 70% in the end of module quiz for modules 1, 2 and 3, and for the final module submit a lesson plan and then peer-review 3 other participants' lesson plans.

## 1.2 Ethical considerations

This research was covered by a formal ethical approval obtained through UCL (UK; reference number STSEth074, approved 4/9/15). The full ethical processes implemented are available on request, and covered aspects such as ensuring participant confidentiality, reasonable opportunity for informed consent, withdrawal, data protection and so on. Most of these are fairly standard, however the informed consent processes took an opt-out approach as follows. Two weeks before the course start date an announcement was individually sent to the enrolled participants explaining the role of UCL, the process of participant observation and confirming ethical approval from UCL. Contact information for the researcher and the course moderator was included in the message and participants were invited to get in touch if they had any queries or concerns.<sup>4</sup> In this report the email conversations are anonymised. Other data on participation activity that is included in this report comes from screen captures of material in the public domain and accessible on the internet. These bricolages of evidence are anonymised and faces are blurred in the photographs to protect individuals' identities.

The researcher started to participate in the MOOC on 1<sup>st</sup> March 2017. She took part in all the discussions and group activities. To avoid conflict of interest she did not submit the summative assessment and was not involved in the peer review process.

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<sup>3</sup> Teachmeet is an online seminar which is organised in such a way as to enable informal sharing of resources, ideas and good practice.

<sup>4</sup> The questions raised were curiosity driven and positive and the researcher was able to use the communication to establish her purpose and make connections. Unfortunately, one person dropped out with the comment that they were not happy about the presence of a researcher on the course.

## 2 Data collection and analysis

Participant observation as a form of evaluation is a variant of ethnographic research (Lecompte, 2002). Ethnographic research is distinctive in that data gathering and analysis are tightly coupled. The move from data to insight, interpretation, explanation, and in general claims making is iterative. As the researcher is in effect one of the participants on the course she does not have access to global activity data but instead experiences the course as a learner (Hayes, 2015), and is part of the visible and less visible unilateral conversations (Conole, 2016).

Unsurprisingly, what it means to 'participate' on a MOOC course is not the same as on a traditional face-to-face training course (Charnet, 2008; Alario-Hoyos et al. 2014). Those enrolled on the *Navigation Through the Ages* MOOC were provided guidance on codes of conduct and how to 'participate' (Cormier, 2010).

Five participation (albeit sometimes overlapping or parallel) stages of the *Navigation Through the Ages* MOOC were evident as follows:

1. **Orientation.** This was about becoming familiar with the timeline, activities, and deadlines, codes of conduct, expectations, times of the live sessions (webinars), and who else was on the course.
2. **Declaration.** The participants introduced themselves, decided on the format for their learning diaries and made their first posts visible to others on the course. Participants posted links to their learning diaries in the MOOC forum, on Facebook or announced it on Twitter.
3. **Networking.** Participants posted responses to tasks and questions prompted by the moderators, and then commented on other people's posts. This activity was mainly via Etherpad<sup>5</sup> and Padlet<sup>6</sup>.
4. **Clustering.** Smaller groups emerged as participants found others with similar interests and priorities and began to collaborate unilaterally. Through various private channels the researcher was able to observe these collaborations. The synchronous small group workshops include the 'teachmeet' and the expert webinar. These were recorded and made available as course content.
5. **Focus.** Most participants worked in small groups of 3 or 4. Participants were invited to submit a lesson plan for final peer reviewed assessment. Learning Designer was used by many participants and some chose to share their work with the whole group. A template and guidance was provided for peer review.

These stages framed the constraints and possibilities for participant observation and data collection.

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<sup>5</sup> [Etherpad](#) an open source collaborative editing tool

<sup>6</sup> [Padlet](#) a digital scrapbook i.e. a web based means of collecting ideas and resources and sharing online



## 2.1 Data

In line with the varied platforms and engagement processes used within the MOOC, data were synthesised from multiple sources across the various stages of participation. The following are some examples.

1. Discussions prompted by tasks and questions. Examples include:
  - Why talk about navigation? “We would like to invite you to post an image you identify with navigation and explain why.” (188 posts)
  - Patterns in the sky (inquiry with Stellarium, an open source planetarium that runs on a PC). “Share your thoughts and comments on how you used this.” (71 posts)
  - The didactic course: The history of navigation – “Tell us three things you discovered from watching the videos of teachers Michael Masson and Eleni Dimitriadi and that you can apply in your classroom.” (173 posts)
2. Synchronous events, for example:
  - Webinar with Cecilia Scorza, Intercultural science - Islamic Heritage Kit
  - Teachmeet with Nair Carrera, Navigation Through the Ages.
3. Videos of teachers implementing an activity followed by discussion “We would like to offer you the chance to exchange with your peers from around the world, and discuss how you would adapt this activity to your subject” Etherpad and Chat.
4. Summative assessment Lesson Plans.
5. Accounts of implementing, adapting, and inventing activities based on the MOOC course. These were sourced across distributed locations e.g. Learning Diaries, MOOC Facebook group, and the MOOC Forum.
6. Researchers’ diary, and anonymised record of private conversations.

All of the above data were harvested from the various social media and online tools used within the course itself (see Annexe 2. Resources and Quick Access Data Map). Where possible they were downloaded in two formats: as a spreadsheet and as a pdf file. As explained in the section 1.2 on ethical considerations, the email conversations are anonymised, and the data bricolages are assembled from screen capture of words and images in the public domain.

## 2.2 Analysis

The data (spreadsheets, pdf and text) were entered into the qualitative analysis programme Nvivo. The analysis was organised in four stages as follows:

**First:** the text and images were coded using terms from the Space Awareness GOs, and insights from online conversations, until a rich picture of participant profiles and

motivations emerged. In parallel to this generative process, instances of contrary evidence, issues, barriers and gaps were highlighted.

**Second:** the data was then reworked to construct a bricolage of images and text to frame the evidence in relation to the GOs.

**Third:** working through the qualitative analysis of data, the participants were segmented based on their motivation for taking part in the MOOC and their role and responsibility.

**Finally:** the contrary evidence, issues, barriers and gaps were revisited to understand the limitations of the analysis.

## 2.3 Participants

On the first day of the course (20.02.2017), 669 participants had registered on the NTA MOOC. Their approximate locations could be gleaned from one of the early course activities. The course introduction included a section on 'Who you will be working with'. Participants were invited to add their location with a marker on the course map<sup>7</sup>. Adding a name and contact information was suggested.

Choosing to enter a location at the beginning of the course can be read as an indicator of intention to participate actively rather than lurk. From the 669 registered participants, 447 entered their location on the map. Most participants entered other information whilst 60 choose to stay anonymous. While some of the locations are not credible (e.g. the middle of the Atlantic Ocean), it is clear that the majority of enrolments were from Europe (see Figure 2). The density of participants was highest in Portugal, Spain, Poland, Greece, Croatia, Serbia, Romania, Turkey and Italy - especially northern Italy and Crete (see Figure 3). Other participants were scattered across the globe.



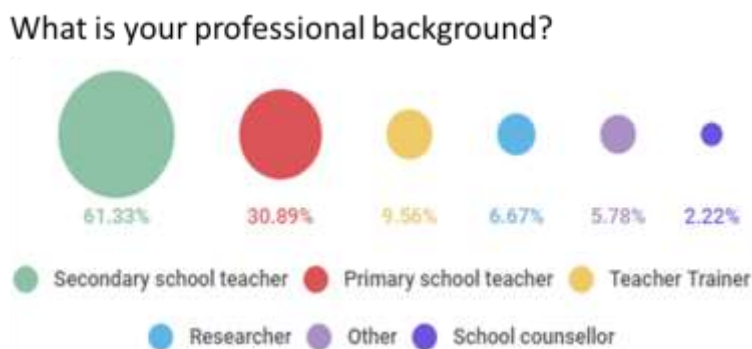
**Figure 2: Global participation map.**

<sup>7</sup> [ZeeMaps](#) a digital map with functionality for individual login and location marking



**Figure 3: Enlarged map of regions showing highest density of participants.**

Infographics<sup>8</sup> profiles of the participants were generated by the course moderators from data entered by registered participants in the pre-course survey, and presented as part of the *Course Introduction - These are the people you will be working with* (20/02/17). The majority of the participants were mature professionals. For example, 75% were aged between 36-55, and 74% had more than 10 years' experience of professional teaching practice.



**Figure 4: Generic group profile of participants' professional backgrounds.**

<sup>8</sup> [Infogram](#) a tool for creating infographics [Navigation Through the Ages participant profile](#)

As illustrated in Figure 4, the vast majority of participants were secondary school teachers (61%) and primary school teachers (31%).

The qualitative evaluation went beyond this group profile into more specific roles, responsibilities and motivations by considering 'why is this participant here?', and 'what impact will their experience on the course have in the future?'. Participation by the researcher made it possible to segment the educators in ways that were not visible from the pre-survey data; see section 0 for reporting of these results.

## 3 Summary of results

This section summarises the main findings from the qualitative evaluation of the *Navigation Through the Ages* MOOC.

Qualitative data augments the findings from the questionnaire by adding images, statements, reflections and narratives. Data is presented selectively drawing from different stages of the course as characterised in section 2. To begin with, section 3.1 describes the finding around the key intended generic outcome (GO) themes, that is: **feel**, **value**, **understand**, **do**, and **skills** (as specified in Table 1). Section 0 describes four categories of participants by considering their motivation for taking part in the *Navigation Through the Ages* MOOC, and their influence and role within the education community. Section 3.3 revisits the GOs to discuss the limitations of the findings reported in section 3.1.

### 3.1 Learning outcomes

There is some overlap in the evidence pertinent to the GOs. However, for consistency across the evaluation reports the GO themes are discussed in separate sections here.

Sections 3.1.1, and 3.1.2 address two set of GOs, specifically **feel** - '*enjoyment, inspiration and creativity*', and **value** - '*values and attitudes*'. The analysis is concerned with how teacher engagement with learning acts as a proxy indicator of future student engagement.

Sections 3.1.3, 3.1.4, and 3.1.5 address the other GOs including: **understand** - '*knowledge and understanding*', **do** - '*actions and behaviours and progression*', and **skills**. The analysis focuses more on implementation in teaching design and how these translate into outcomes for students.

Findings are fleshed out with evidence from teaching plans developed by the teachers and published in Learning Designer<sup>9</sup>. Table 2 is a list of the teaching plans that are referenced throughout section 3. The teaching plans are rich cases for evaluation of the GOs, however it is worth noting that only a limited number of teaching plans were made visible to all participants in the MOOC. In the final stage of the MOOC, participants were working in very small groups. It is likely that only the most confident published their work widely, and from

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<sup>9</sup> [The Learning Designer](#) is a set of tools that teachers used to design and share lesson plans.

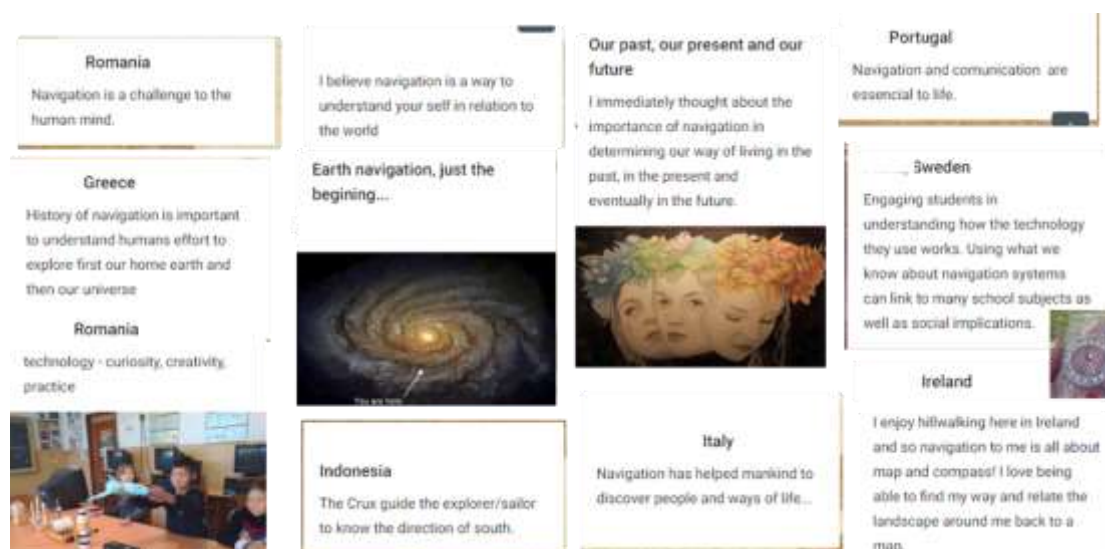
these, the 10 plans in Table 2 are open access and therefore suitable for direct consideration in this report. There is no reason to suppose that these peer reviewed lessons will not be delivered and shared more widely with other teachers.

	Lesson Plan	Subject(s)
1	<a href="#">Discovering the ancient town of Pompeii</a>	History/Geography/Fieldtrip
2	<a href="#">Navigation using GPS</a>	Geography and Science
3	<a href="#">Valle dei templis stars</a>	Geography
4	<a href="#">Latitude and Longitude</a>	Space Science
5	<a href="#">Orienteering through earth by the sky</a>	Geography
6	<a href="#">Orienteering though the constellations</a>	Science
7	<a href="#">Sun up sun down</a>	Science
8	<a href="#">Big bang theory</a>	Space Science
9	<a href="#">Constellations</a>	History/Geography/Language
10	<a href="#">From archaeoastronomy to Galileo</a>	History and Science

**Table 2: Sample of teaching plans. These are referenced throughout this section.**

### 3.1.1 *Enjoyment, inspiration and creativity*

In the first module educators were invited to post an image and a statement on “[Why talk about Navigation?](#)”. The responses (188 posts) suggested inspiration and positivity. This was invoked in comments about the vastness of the universe, in marvelling at human capability, ingenuity and achievements, and showing pleasure in instruments past and present.



**Figure 5: Bricolage of positive statements and inspired photographs.**

This reading of ‘feelings’ - which tends awe and wonder - is supported in data from another activity in which participants were asked to share a word or sentence they associated with



the topic of 'Navigation'. The software tool logged 145 entries and the most frequent terms entered were 'navigation, stars, sky, space, curiosity, discover and travel and knowledge'. The bricolage of data in Figure 5 captures something of this enjoyment and engagement.

There is evidence of teachers feeling confident about teaching space topics and that this confidence is being translated into activities that students enjoy. This is illustrated in Figure 6 which is a bricolage of teachers' comments following an exercise using Stellarium software on the theme of '[patterns in the sky](#)'. The comments capture some of the pleasure that the teachers felt in this practical activity and their intention to use it with students. Extrapolating from this it is likely that teachers' feelings and engagement will enthuse their students.



**Figure 6: Indications of teachers' confidence to inspire students.**

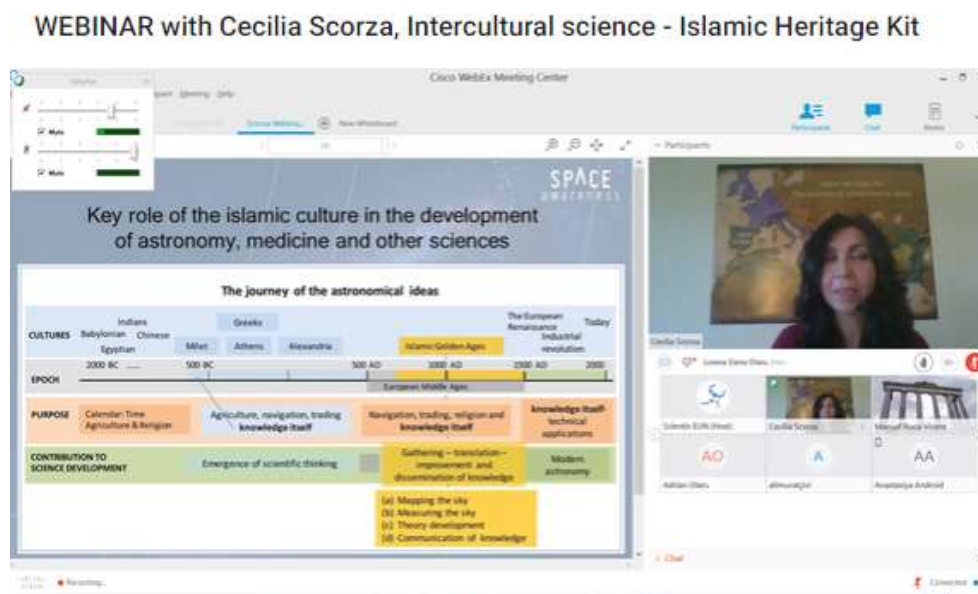
### 3.1.2 Values and attitudes

The questioning structure in the modules modelled best practice pedagogic techniques for recognising diversity, the contributions of men and women to space science and valuing global citizenship. Questions which elicited the longest contributions and subsequent discussion asked participants to share local knowledge. Here are two examples from module 1 and 2.

- End of module 1: Introduction to navigation through the ages**  
 What is archaeoastronomy?  
 Advances in navigation reached the heights of today by the contributions of numerous civilizations.  
 Share in the [Padlet below an example of archaeoastronomy](#) (for example, a building) in your country and tell us how you would use it to teach a lesson in your subject. (158 posts)
- Mid-module 2: The History of Navigation**  
 Some historical facts related to navigation.  
[Share with us some historical facts related to navigation](#) in relation to your culture and history. (115 posts)

These questions are interesting because they prompted discussion about the contribution of different cultures to science and engineering. Additionally, this information was reposted in a number of diaries with some teachers saying they would use both the form of questioning and the information generated as a teaching resource to engage students in similar collective tasks.

In a similar way, even though there were only a limited number of places to take part in the webinar on Intercultural science education by Cecilia Scorza, the material was widely reposted. Figure 7 illustrates an insert from a Learning Diary, and is an example of such sharing and intended re-use of resources.



**Figure 7: Example of cumulating resources to reuse in classroom activities.**

A similar effective dual recognition occurred in relation to prompts about space science contributions to everyday life, with the question “Imagine you want to tell a friend about the place you are at this moment. Which information would you give to your friend?”. There were 125 posts in response as well as much private discussion and humour. The teachers found the exercise stimulating themselves, but also saw its relevance for encouraging conversations in their classrooms. For example, one of the participants reported asking her 6-year old son who told her he was sitting in a car between a red car and a blue car! [paraphrase of [post in Padlet](#)]. As another teacher said:

*“from the taken for granted to the ridiculous, from the very modern to the ancient, every possibility was raised by somebody in the group, it would probably work even better in the classroom.” [private email correspondence]*

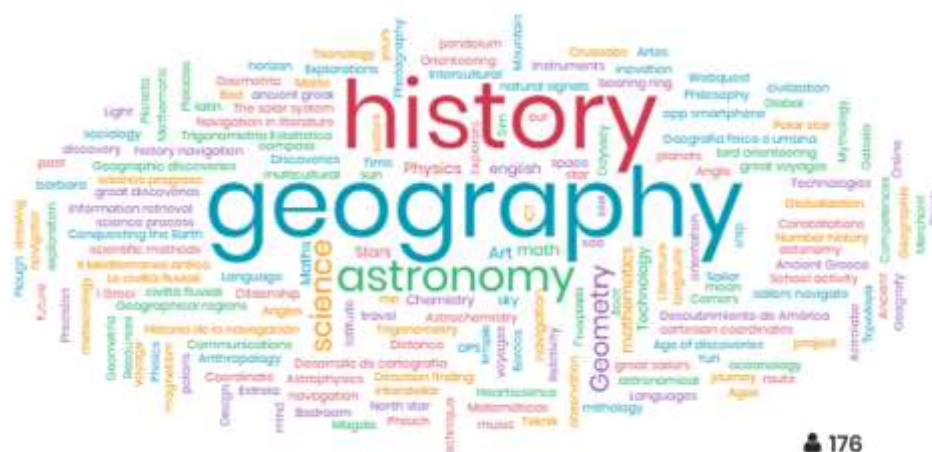
### 3.1.3 Knowledge and understanding

This section first reviews positive evidence relating to the knowledge and understanding GOs, and then discusses the gaps.

The first module covered topics like *The history of navigation*, and *The importance of measuring space and time through the ages*. After this, participants were invited to propose three subject areas or topics that could be addressed using the navigation theme. 176 participants contributed to a word map<sup>10</sup> (Figure 8). As might be expected, *history*, *geography*, *astronomy*, *geometry*, and *science* were cited most frequently. However, what is interesting is the diversity of other ideas, including using the navigation theme to teach - *Latin*, *magnetism*, *photography*, *globalization*, *sociology*, *design*, *science method*, *music* and *mythology*.

#### Activity

Do you think this topic could be incorporated in the school curriculum? Please point out three subject areas or topics you think that could be addressed using the navigation theme.



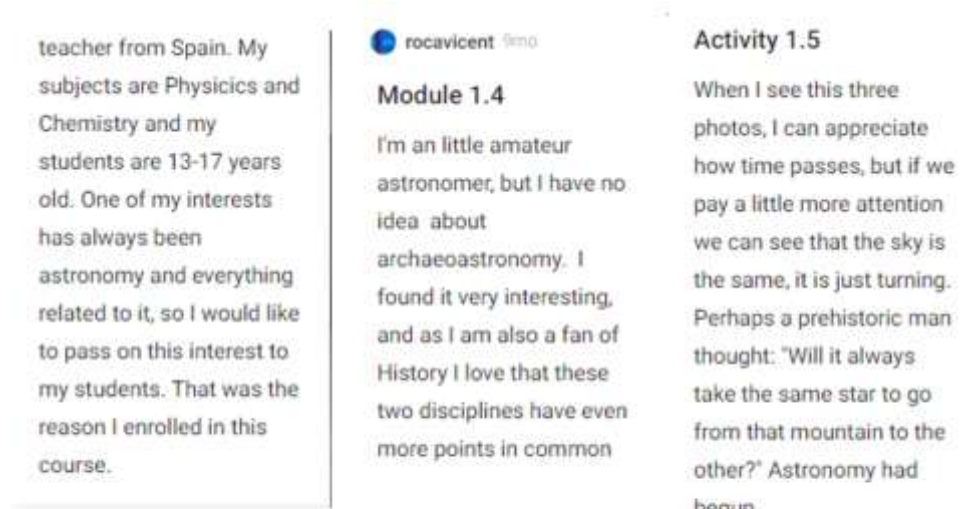
**Figure 8: Diversity of ideas on topics that could be taught using the navigation theme.**

From the participant introductions, and posts in the learning dairies, it was clear that educators that participated actively in the *Navigation Through the Ages* MOOC taught a variety of subjects, and came from a range of disciplinary backgrounds. Some of these are not too surprising, for example science and mathematics, geography, history and astronomy. In addition to this, the course attracted teachers who taught, for example: English, philosophy, geology, languages, special needs and art.

As a participant, the researcher noticed that questions around ‘disciplinary training’ and the ‘subjects that educators teach’ did not have straightforward answers. For example, from email conversations it emerged that one teacher taught geography, science and civic studies across two schools. A number of teachers taught more than one subject, and ran an astronomy club after school. Many of the educators showed themselves aware of the possibility of using space science for teaching many disciplines including cross discipline projects and non-science subjects as illustrated by the collection of posts in Figure 9 .

<sup>10</sup> Generated using [Mentimeter](#)





These courses provide ideas, materials and topic to help introduce topics that are not usually found in the curricula of the discipline but it can be adapt to illustrate to students concepts and typical topics from other disciplines in traditional teaching. Moreover, these methodologies should illustrate the European dimension of teaching and learning.

**Figure 9: Collection of posts on the course knowledge content.**

The non-hierarchical networks and international sub-groups in the MOOC had a rhizome effect, enabling participants to pursue their own goals and interests and adapt knowledge from the course for their own purposes. It was evident, for example in the long posts about [archaeoastronomy](#), that many participants shared a passion for astronomy, making connections between disciplines, and between the global and the local. The following two examples suggest that knowledge content in *Navigation Through the Ages* was well received and indeed adapted to suit local needs.

At the Teachmeet event on 17<sup>th</sup> March 2017, course participants were invited to submit a presentation to showcase innovation. Four [participants presented](#). One of the presentations built on the course topics *Celestial Navigation Concepts*, and *Celestial objects and instruments*. In this presentation an outreach teacher / teacher trainer described how she had designed a process for the construction of an instrument, a quadrant, for astronomical measurement. In her presentation she explained how she travels around the municipality of Rio de Janeiro to work with diverse groups of boys and girls, and teachers, to make the quadrant locally with recycled material, and then use it as an astronomical instrument (see Figure 10). Her work is an example of how educators engaged with the course knowledge to make Space Science accessible.



**Figure 10: Teachmeet presentation on using recycled material to construct a quadrant**

Finally, some of the more detailed evidence that knowledge from the course was reaching the students comes from the teaching plans that the teachers submitted for peer review assessment. All the plans in Table 2 demonstrate adaption of knowledge from the MOOC *Navigation Through the Ages*. Figure 11 is a screen capture from the Learning Designer of a plan to teach "[History of Navigation from Archaeoastronomy to Galileo](#)". It shows that all the module content from the MOOC has been adapted for teaching 5 lessons to a class of 20 secondary school students.

THE HISTORY OF NAVIGATION FROM ARCHAEOASTRONOMY TO GALILEO	
<b>Name</b>	THE HISTORY OF NAVIGATION FROM ARCHAEOASTRONOMY TO GALILEO
<b>Topic</b>	HISTORY OF NAVIGATION
<b>Learning time</b>	600 minutes
<b>Designed time</b>	365 minutes
<b>Number of students</b>	20
<b>Description</b>	Five lessons about the fascinating history of navigation. This course answer to these questions: 1. How did early sailors navigate the oceans using only mechanical instruments (i.e. sextant, compass, sundial, astrolabe, etc.)? 2. How the ancient knowledge of the sky helped the ancient sailors to navigate oceans? 3. How maths contribute to the modern navigation? 4. How the Global Navigation Satellite Systems and Galileo project contribute to our daily life?
<b>Aims</b>	Development of: - Teamworking for the harmonious and balanced collaboration; - Critical Thinking "constructed" by the reading of scientific and historical article, by watching videos and discussing about important themes about topic; - Active Learning and Time Management teaching the importance, in the Teamworking, of managing time to reach an objective. - Meta-cognitive competences.
<b>Outcomes</b>	<b>Knowledge:</b> Basic knowledge of the history of navigation. <b>Application:</b> Application of acquired knowledges: to writing various texts, mainly newspapers articles.
<b>Editor</b>	LucaM

**Figure 11: Teaching Plan reflecting key MOOC themes**

In this MOOC, the main gap was in consolidating the messages in the videos on space science careers. A number of participants reposted the career interview videos in their learning diary, which suggests that they were considered a useful resource. It also suggests that teachers envisaged showing them to their students, since the videos were regarded as a valuable resource for designing lessons. Knowledge of MOOC content, including content relating to space careers, was tested by multiple choice questions at the end of each module, with a required pass mark of 70%. However, the content on space science careers was not explicitly a discussion topic at any point during the MOOC. The rubric on assessment did not mention the career interviews, and appreciating that people who work in space science are real people did not arise in discussion, either prompted or unprompted. Overall, the careers videos were published as a stand-alone resource and there was no scheduled activities or observable discussions around those resources.

Participants in the *Navigation Through the Ages* MOOC were referred to content on diversity in the *Teaching with Space and Astronomy in your Classroom* MOOC. This is interesting because the link to the Space Awareness MOOC exposed the participants not only to content on strategies for inclusive teaching but *also* to archived discussions on career opportunities in Space Science. Here are two examples from module 5.1 and 5.2:

**MOOC: Teaching with Space and Astronomy in your Classroom**

*Module 5.1 Introduction to Space Careers*

Space Careers and School Subjects

Think about which of the careers can you link to certain school subjects, which of them fit to the subjects you teach. And how could you integrate these into your lessons? Share your ideas and reflections on this in the Dotstorm. And vote for ideas from your peers which you find particularly insightful or useful. [Link](#) (need to register on European schools net to access)

*Module 5.2 How role models impact young people's space-oriented career choices*

National Space Role Models

See if you can identify a national role model in space/astronomy. In some countries you might have to do a bit of research first. Write how this person fits with what you've learned in this activity and share with us at least one idea about how you will integrate him/her in a lesson with your students. [Link](#)

Some of the content from the archived discussions were aired in small group conversations. One teacher said:

*"I played the space science and engineering career videos to my students at break time and they are really quite interested. I don't know this myself and need to find out. I am exploring the Space Awareness Website and will enrol on the other MOOCs" (Private conversation)*

It seems that while the intended outcomes relating to space science careers were not addressed directly in this MOOC there was a vicarious learning effect from archived activities in the other MOOCs.

**3.1.4 Do: Action, behaviour and progression**

Many of the participants celebrated their progress by posting module badges in the MOOC Facebook group and in their learning diary. Clearly participants wanted certification as evidence of professional development, but their engagement with knowledge was not

wholly instrumental. There was evidence of action following from participation in the course, mainly in data from the teaching plans submitted for peer review (see Table 2), and in posts and photographs showing children and young people engaged and absorbed, and examples of their work.

Teachers who published their teaching plans accessed and used Space Awareness activities confidently. Materials and activities from the *Navigation Through the Ages* MOOC were adapted in teaching plan lessons across multiple disciplines including Geography, Science, History and English (see Table 2). Teachers also extended or combined ideas to create new experiences for their students. For example, in "[Navigation using GPS](#)" students are asked:

*"What are the best ways to explain our position to someone who is a long way from us, for example if we are in the middle of a large mountain range?"*

This is adapted from one of the exercises that the participants tried out themselves in the MOOC. The teaching plan proposed that students would view videos on navigation from the MOOC and the teacher then incorporated a new additional related activity:

*"...using smartphones or tablets students learn to score positions using the OSM Tracker App for Android."*

In another adaptation (see Table 2) entitled "[Valle dei templis stars](#)", the students used the Stellarium software introduced in the MOOC, recorded their team work in Padlet and then presented their work to the rest of the class.

A behaviour pattern observed by the researcher was that the learning diaries were used as extended memory to organise quality teaching and learning resources, and especially video links. These resources were integrated into lessons as a means of explaining concepts and transmitting content, and as an alternative to the teacher simply talking. The majority, 9 out of the 10 teaching plans (see Table 2), incorporated videos as an integral part of the lesson design. As one teacher commented:

*"There are a lot of videos out there but it takes time to see if they are good or will work. In the MOOC we can take it all in one package. "(anonymised private correspondence.)"*

In other lesson designs, learners were asked to investigate their local environment and history and explore navigation through related activities in which *knowledge, skills and technology* are embedded. The following are some examples of how this influenced lesson design:

- "[Navigation using GPS](#)" is designed around knowledge of the Galileo satellite system and its implications for communication and everyday life.
- "[Discovering the ancient town of Pompeii](#)" is about the Greek invention of navigation instruments and the role of this technology in the history of the local town of Pompeii.
- "[Portuguese Discoveries and the Big Bang Theory](#)" facilitates the students to discuss the ideas of Aristotle, Copernicus, Bruno and Descartes. They investigate the



Doppler effect, the red shift, the blue shift and the big bang theory. Finally, they present their conclusions on the nature of the universe in a newsletter.

Lessons plans indicate that the MOOC was influential in steering teaching practice. Space science was used for teaching in many disciplines including cross-disciplinary contexts and non-science subjects. Although the lesson plans do not necessarily reflect actual delivered sessions, they do indicate a strong commitment from the participating teachers to take on board the content covered in the MOOC, thereby improving their teaching practice.

There was also some evidence that students were engaged in lessons inspired by the resources and activities in the MOOC. The images in Figure 12 are snapshots and few in number, but they do suggest that children and young people benefitted when teachers translated their positive experience from the MOOC into their teaching practice.



**Figure 12: Indicators that children and young people are beneficiaries.**

Finally, networking is a form of **doing** and action. Educators shared links to space science career videos via Facebook and Twitter, and shared other links as in the example in Figure 13. The teachmeet and webinars as a space for networking, showcasing and celebrating innovation has already been mentioned. Another channel of productive activity took the form of announcements in which teachers invited collaborators. For example:

*"I'm an Italian primary school teacher .....I would like to develop a long-term project with some same age group classes from different countries to .....explore Navigation through the Ages" projects. Are there any teachers interested in developing this project with me?" Facebook post March 23*

There were a number of these and the researcher was aware of 5 ad hoc groups of enthusiastic teachers organising enriching informal collaboration.



**Figure 13: Career link posted in the MOOC Facebook group and on Twitter.**

These insights suggest that there is a world-wide community of teachers who are comfortable in the MOOC environment and benefiting from Space Awareness activities, resources, and networks. This cumulative effect is a promising positive impact beyond the end of the project.

### **3.1.5 Skills: space science, teaching and learning, ICT**

The skills that were highlighted in this MOOC centred on (1) Inquiry Based Learning (IBL); (2) ICT in teaching space science; and (3) strategies for inclusive teaching.

For all of these, the *Navigation Through the Ages* MOOC included content in the form of lecture videos, and videos of teachers implementing inquiry-based learning, and activities with the ICT tools.

<p><b>Fiona, Sweden</b></p> <p>I like the interdisciplinary approach. I see obvious similarities with 'reciprocal teaching' which is often used for language learning and 'Philosophy For-Children' which is an approach I use a lot in science class. It relies on have a good stimulus and helping kids to develop key questioning skills. Questioning skills are important for IBL.</p>	<p><b>Daniela Lazzaroni Italy</b></p> <p>I'm not a Science teacher, I teach English in a secondary school, but I use the same activities in order to involve my students. I also use group works. I think it is very useful to involve students, introducing the lesson through brainstorming, for two reasons: 1 they learn about the new subject; 2 it is an occasion to speak in English.</p>	<p><b>Ezzarg, Morocco</b></p> <p>The invasion of technological tools of games, for example smartphones, tablets ... our children become more and more egocentric. It was very interesting to know how to motivate them, make them work in groups, collaborate and communicate with others and find daily uses for the project and the experiences in class.</p> <p>These two video inspires me</p>	<p><b>Manuela Mendes, Portugal</b></p> <p>Inspirational videos, that makes me think about :</p> <ul style="list-style-type: none"> <li>- involve my students (introducing the lesson through brainstorming)</li> <li>- collaborative work and the discussion</li> <li>- learning by doing (with laboratory or outside activit)</li> </ul>
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**Figure 14: Examples of teachers reflecting on their practice.**

It is noteworthy that teachers' attitudes were influenced by watching other teachers talking about their innovations, and through footage of classrooms in which the MOOC resources and inquiry-based learning were demonstrated. The [posts by teachers](#) that followed were

overwhelmingly positive. Some of this is illustrated in Figure 14. Even teachers who were already familiar with inquiry based learning and/or already used ICT said they had learnt something. There is a sense that these videos were creditable and provided food for thought and action. There was also a lot of talk of inspiration, as well as evidence of shifting attitudes and values towards learner-centred activities and active pedagogies. The reflections by teachers from different parts of the world and from different education systems is evidence for intended outcomes relating to skills as well as changing values and attitudes.

## 3.2 Educator segmentation

Data from learning diaries suggests that curiosity and student-centred values are central to the participants. Based on people that the participant researcher observed and talked to, the participants can be usefully segmented based on their motivations for taking part in the course and their professional role and responsibilities.

**Interdisciplinary Advocates.** This group of teachers were motivated by interdisciplinary innovation. These teachers do not have a background in science, and are actively pursuing an interest in using astronomy to teach non-science subjects, for example history, geography, languages, citizenship, and special needs. Some were 'discovering' the excitement of science as adult learners, and as confident teachers were able to make wide ranging connections:

*"I work near Imperia (Italy), known for a big festival of old sailboats. I graduated in Foreign Languages and Literatures at Genoa University, with a thesis about "Letters of Travel" by Rudyard Kipling. I am a foreign languages teacher with a specialisation in special needs education so I teach every subject to students with special needs at the Secondary School. I grew [up] with the idea that I was not gifted for Science, but observing my Science colleagues I find their lessons very interesting and motivating for students and now I believe that Science is fascinating and can be for everyone. I love travelling around the world physically and virtually and reading makes me travel with my mind :)" [emphasis in the original]*

This is an important target group for promoting effective science communication across the education system.

**Strategic Developers.** This group of teachers identified themselves as primary or secondary school teachers in the survey, but importantly they also have management and developmental responsibility for the whole school, or region. For example, school events, enrichment activities, curriculum development, staff development, eTwinning initiatives and cross-school collaborations. This means they are in a position of power to influence other teachers and lead new developments. This group was active in other STEM networks and in deploying other Space Awareness Resources. Members of this group possibly have the power and position to lead strategic, whole system, changes for embedding space science into the curriculum at local, regional, and occasionally even national levels.

**Outreach Experts.** This group of participants introduced themselves as educators affiliated to national and local astronomy institutions and advocacy organisations.



**Figure 15 : Examples of educators affiliated to national astronomy institutions.**

Some enrolled on the course as former or part-time teachers. This group is distinctive in that the educators in the group had a voluntary or formal outreach role in engaging teachers, children and young people in space science (for examples see Figure 15). This group consists of people with a passion for astronomy. Their influence comes from their voluntary and expert status. Some of them have a media presence and are nationally famous. It will be important to include members from this category in steering groups that shape the future of space science education.

**Classroom Enthusiasts.** This was probably the majority group and most visible in the published learning diaries and in private conversations with the researcher. This group was made up of classroom teachers in search of new resources, ideas and ICT tools. These educators accumulated resources, knowledge and ideas, ICT tools and pedagogical techniques. These resources were adapted directly for their classes and extracurricular clubs. Their interest in the MOOC centred around Continuing Professional Development and networking possibilities. This motivation was shared by primary school teachers without a science background *and* secondary school science teachers. Both groups shared a passion for astronomy, space science and for education.

These categories are interesting because strategic developers and outreach advocates were most visible in posting in the MOOC Facebook group and via twitter. Additionally, it is possible that many teachers may have been invisible even to a participant observer if they did not actively contribute in any way during the course.



### 3.3 Contrary evidence, and limitations

The vast majority of the participant observation data were highly positive. There was clear evidence of the majority of the intended MOOC outcomes being met, and the atmosphere was generally enthusiastic, proactive and encouraging. To balance the apparent selectiveness in the data presented, this section discusses four of the more problematic findings and limitations of the study.

First, contrary evidence was observed within each of the intended generic outcome (GO) categories. Taking the 'feel' outcomes firstly, whilst the majority of participants exhibited feelings of awe, wonder, inspiration and enthusiasm, some participants did mention being lost and overwhelmed in module 1. After that point they simply disappeared. They may have decided to either lurk and not actively participate, or they may have dropped out. It was also the case that when participants were negative, they were crowded out by the majority as they attracted fewer public responses to their post. The dropout rate was not visible to the participant observer, however she was in touch with three participants who decided to stop participating because of workload issues, and one that decided to lurk due to ill health.

Second, in private conversations some participants said they had too much choice in where to publish their learning diary and lesson plan. The result was that the posts were quite scattered and it was difficult to find new materials/contributions posted by other participants. On the other hand, some felt that Padlet, as the primary space for interaction, was overused as a posting tool. The technical and logistical barriers to learning in a MOOC are not new to *Navigation Through the Ages* (Hayes, 2015). In that light, *Navigation Through the Ages* was unusual – it was experienced as a lively and busy MOOC throughout.

Third, the obvious gap, discussed in section 3.1.3 on 'Knowledge and understanding', was in the absence of any discussion or explicit activity relating to space careers. Never-the-less there were links to discussions in the previous MOOC and to careers interviews relevant to the content of the *Navigation Through the Ages* MOOC.

Finally, the limitations of participant observation as a means of evaluation are self-evident. While the researcher is able to build up a rich picture from her observations, and data that is available, there are some limitations. Over time it was only possible to observe an ever-smaller network within the MOOC, and it was only possible to see the data that participants wanted to be seen. In addition, many of the diaries and lesson plans that were visible during the course are now broken links or switched to private access by the participants.

## 4 Conclusions

Theme	Intended learning outcome				Rating
Feel	Enjoy learning / teaching about space				Green
	Feel confident teaching space topics				
	Feel inspired by space science				
	Feel positive about space science				
	Aspire to space science careers				
Value	Value the diverse contributions of many different cultures to space science				Green
	Value the contributions made by both women and men to space science				
	Appreciate that space science contributes to everyday life				
	Appreciate that people who work in space science are real people				
Understand	Highlights of space science (Navigation through the Ages)				Green
	The impact of space science on society and everyday life				
	Space science can be used for teaching in many disciplines including cross-disciplinary contexts and non-science subjects				
	Space science career opportunities are diverse, rewarding and highly accessible (particularly to girls and ethnic minorities)				
	Career opportunities in space science and technology at all levels				
	Relevant pathways to these career opportunities				
Do	Access and use Space Awareness activities confidently				Green
	Create own content and additional activities on the same or related topics				
	Want to learn more about space science				
	Choose or consider choosing, or encourage others, to study and pursue careers in space science and engineering or science and engineering more widely, especially girls and ethnic minorities				
	Share their understanding of space science and technology with learners, peers, family and/or their community				
Skills	Develop inquiry-base skills for teaching/learning about space science				Green
	Learn how to use IT to teach/learn about space science				
	Learn how to be more inclusive while teaching, particularly for girls and minorities				
Strong evidence this outcome was achieved	Strong but sporadic evidence this was achieved	Some evidence this outcome was achieved	Evidence this outcome was NOT achieved	No evidence either way	

**Table 3: Summary of achieved outcomes**

Participant observation was used to augment the MOOC survey data and collect qualitative evidence in relation to intended learning outcomes. Data from observation included both content and interaction visible through a normal participation experience. This included: participants' posts to set questions, learning diaries, a recorded Teachmeet and webinar, Facebook posts, and assessed lesson plans. Anonymised data was also collected through private email and chat channels.

From the participant point of view, 669 colleagues registered for the MOOC, of whom 447 entered their location on an initial map, suggesting an intention to actively participate. Module activities attracted around 70 to 190 separate posts, representing active engagement with the MOOC content and discussions. Around half these participants shared their learning diary and assessment. The researcher was also able to move between smaller groups and talk to participants individually through private channels (email and chat).

The evidence in relation to the learning outcomes is summarised in Table 3. In general, there was 'strong' or 'sporadic but strong' evidence relating to all the specific outcomes (dark and light green in Table 3), *except* those that relate to space science careers and career opportunities. For the latter, there was either little or no evidence (yellow and grey).

The career-specific learning outcomes are distributed across the five intended generic outcome themes. There is evidence, in the learning diaries, that the excellent career videos were accessed and harvested as a valuable resource. However, the researcher did not observe or find any traces of discussion or practical activities relating to career-related resources on this MOOC. This does not mean there is no evidence, as it could be a limitation of the method. Some groups and activities are simply not visible to all participants. Where some evidence is indicated in relation to space career related outcomes (yellow), this is because participants completed a quiz showing understanding of the content, including space career related content. Those who moved to the final module must have scored more than 70% on this knowledge test. In addition, participants were guided to explore discussions on careers in space science in the previous archived *Teaching with Space and Astronomy in your Classroom* MOOC. The effect of this action was positive for participants in the *Navigation Through the Ages* MOOC.

What emerges from the rich data is that space science is well positioned to engender inspiration, enjoyment, curiosity and wonder, and that MOOC resources deliver this emotional connection. There is strong evidence of positive feelings around the topic of *navigation*. There is also proxy evidence, from the teachers, of students experiencing the same feelings. Educators **feel** confident about teaching the topics covered in *Navigation Through the Ages* and there is evidence in the learning diaries that they emerge from the course with a valuable set of resources. In the MOOC, educators were given access to content, examples of practice, and then asked to reflect and discuss. There is evidence that this was an effective strategy for the group to collaboratively process **attitudes and values** in relation to science and culture, citizenship, diversity, and relevance. The teaching plans are indications that teachers translated their experiences into similar activities for their students.

For the remaining intended generic outcome themes (GOs): **understand, do** and **skills** there is strong supporting evidence that is relevant for all three themes. The evidence around the **understand** GOs came from a number of sources. The posts in the learning diaries are evidence that the MOOC provided valuable and engaging highlights from space science. The material on 'patterns in the sky', and the European Global Navigation Satellite System, was especially well received and used with students to explore the impact of space science on society and everyday life. In the teaching plans, and teachmeet session, the educators presented evidence to showcase their own content and additional activities building on the

MOOC resources. This included using astronomy to teach geography, history, English, special needs as well as primary and secondary school science. For teachers who had no science background there was a sense of discovering a treasure trove of resources for teaching their subject and they certainly expressed a desire to learn more about space science with their students.

Many of the participants celebrated their progress through the modules by displaying their module badges and by exchanging good wishes. Clearly, progress and recognition by certification was important to them. The evidence for the GOs around the **do** theme comes from combining data from the teaching plans submitted for peer review, with posts and photographs showing how this knowledge and understanding has been translated into practice. Teachers who published their teaching plans accessed and used Space Awareness activities confidently. Materials and activities from the *Navigation Through the Ages* MOOC were adapted in teaching plans across multiple disciplines. There was evidence that educators introduced their classes to many of the Navigation topics introduced on the MOOC, as well as specialist software. In other words, the educators adapted many of the activities and tools they tried themselves in the MOOC. The method of participant observation uncovered other positive actions that can be classed as **doing**. This included showcasing innovation, sharing resources and even initiating informal networks of international collaborations.

Most of the educators taking part in the MOOC can be described as experienced and mature professionals. Most teachers had come across some variant of inquiry-based learning, astronomy specific software (e.g. Stellarium), and various ICT teaching tools. Nevertheless the teaching plans and peer review accounts are evidence that the MOOC enabled thinking about balanced pedagogy and embedding video resources in lesson design. In relation to the **skills** theme, and it was especially encouraging to see the MOOC space used as a CPD collegiate space. It was evident that the MOOC had a rhizome effect as participants were able to pursue their own goals and interests and make their own connections with each other, between disciplines and between the local and global. From this evidence, it is reasonable to claim that the *Navigation Through the Ages* MOOC was an empowering experience for the participants that completed the course.

Finally, the richer picture of participants suggests that the participants can be usefully segmented based on their motivation for taking part in the course and professional role and responsibilities. Four categories were described: (1) **Interdisciplinary Advocates** - teachers motivated by interdisciplinary innovation; (2) **Strategic Developers** - teachers with management and curriculum development responsibilities; (3) **Outreach Experts** - educators affiliated to national and local astronomy institutions and astronomy groups; and (4) **Classroom Enthusiasts** - classroom teachers in search of CPD, an extended network and inspiring resources. These insights suggest that the MOOC attracted actors from different professional worlds with contrasting motivations. A fortuitous result was that the MOOC became an enriched space for innovation to flourish.

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## 6 Appendices

[Annexe 1. Email sent to Navigation Through the Ages MOOC participants](#)

[Annexe 2. Resources and Quick Access Data Map](#)



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