

The IGS and the Education of the Next Generation of Users

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Education/to educate:

“... the imparting and acquiring of knowledge through teaching and learning ...”

“... systematic instruction or training for a particular calling, practice, etc. ...”

“... the development of knowledge, skill, ability, or character by training, study or experience ...”

1. Introduction

Education is an issue that concerns every one of us. That may sound trite coming from a professor at a university. But no, I mean it. All sorts of organisations are focussing on this issue: major businesses, associations (including voluntary ones), and even NGOs. Scientific and professional associations have also increasingly been concerned with “education” (and its closely-related cousin: “outreach”). This paper will focus on the situation within one of the services of the International Association of Geodesy (IAG): the International GPS Service (IGS).

It wasn't so long ago that scientific associations, and especially ones with an international membership or focus as in the case of the IAG/IGS, were concerned only with the *generation* of knowledge, and “*reporting*” (some believe that this is a form of “education”) of the most recent scientific results at prestigious (exclusive? narrowly-themed?) conferences, and in high-impact (“high brow”? esoteric? obscure?) peer-reviewed publications. So what has changed? Such associations in the past were never concerned with the education of “peers” by their peer. *Perhaps there is a recognition that the audience, or the “consumers” of the products and services of scientific and professional associations has changed (or should change)?*

Whatever the formal definition of “education” may be, I believe it is an activity that is directed to (and for the benefit of) *the next generation of researchers, the wider community of users, and even society in general.*

Although professional organisations such as Institutes/Associations of engineers, navigators, geographers, etc., have long had programs of education, or “professional development” as it is often referred to, more recently the broader goals of “education” have also become incorporated into their business strategies or mission statements. But as education has traditionally been the role of “educators” (taken to mean principally those *researchers* working within tertiary *education* institutions such as universities), this does raise some issues. For example, where does “advanced training” fit? Who educates the critical users on how best to apply the latest knowledge in their field? In the context of the IGS, the users need to “apply” the methodologies of GPS Geodesy, through the correct use of high precision IGS products.

Another example is explicit “K-12” education. Is it truly education in the classical sense, or “outreach”, or “marketing”, or even just a grab for attention of the next generation of users, researchers, and (most

importantly) politicians/community leaders? It seems that “education” is sometimes viewed as a tool for gaining “market share”. But which “market”? Maybe it is the finite attention span of prospective students and critical constituencies? We want people to make the right “choice” (that is, to choose our expertise, our products/services, our scientific discipline, our university programme, etc.), therefore we must first “educate” the consumers. And the younger we start the better!

So, the questions need to be asked. How broad is our view of “education”? What are the objectives of discipline/association-specific education? What are the delivery modes for such education? Who is the “educator”? How central is the “education function” vis-à-vis the primary mission of a scientific/professional association?

In this paper I do not propose to explore such broader themes, but rather look at the IGS, its mission/vision, and strategies to achieve its goals; past educational activities (or lack of them); and explore some options for future educational and outreach activities. However, it is difficult to avoid not placing IGS-relevant education in the wider context.

2. GPS Geodesy, the IGS and Education: “The Good Old Days”

The beginning of the 1980s saw the first civilian innovations and applications of the Global Positioning System (GPS) technology -- in the form of the development of carrier phase-based techniques first for the establishment of geodetic networks and later, as the precision and reliability of GPS improved, the addition of GPS to the space geodesist’s toolkit. The 1980s were therefore the dawn of “GPS Geodesy”, and by the end of the decade GPS had revolutionised the *operations* of geodetic surveying and *geoscience* of regional geodynamics. It was in this heady era of GPS Geodesy that we saw the first proposals for the establishment of permanent, continuously operating GPS reference stations which ultimately led to the setting up in 1994, by the International Association of Geodesy, of the International GPS Service (Beutler, 2004).

It is worth noting that the original acronym for the IGS was the “International GPS Service for Geodynamics”, identifying clearly the first intended users of such a service. In fact, according to Ibid (2004) *“the primary motivation in planning the IGS was the recognition in 1989 that the most demanding users of the GPS satellites, the geophysical community, were purchasing receivers in exceedingly large numbers and using them as more or less black boxes, using software packages which they did not completely understand.... The other motivation was the generation of precise ephemerides for the satellites together with by-products such as Earth orientation parameters and GPS clock information.”*. It is also clear from this quote that the IGS was intended to service the most demanding of civilian GPS users at the time, the geoscientists. They did this (and continue to do so very successfully) by generating *products* that would support their precise positioning application.

However, that was only part of the story. The IGS (through its component parts) also developed a body of “GPS Geodesy” *methodology*. Furthermore, in addition to servicing the researchers within the geosciences, the IGS (through its provision of a set of high quality products) played an invaluable role supporting national geodetic agencies in their tasks to establish modern, geocentric reference frames for surveying and mapping. The IGS infrastructure of permanent GPS tracking stations, the precise ephemerides and tracking station coordinates, and the “recipes” for the correct operation of sophisticated “scientific GPS software”, all have contributed in making GPS now the premier space geodesy technique for almost all operational and fundamental geodetic research applications.

Hence from the beginning the IGS was addressing the needs of two classes of users: the operational geodetic surveyors and the geoscientists. *So how were these users “educated” in the correct use of IGS products?* Although a generalisation, it is fair to say that the majority of geoscientists became GPS Geodesy experts as a by-product of university-based research. During the 1990s a large number of graduate students gained their PhDs by “doing GPS Geodesy” projects. That is, it was essentially a *self-education process*, where graduate students and their supervisors “learned by doing”. Data gathering campaigns were organised, and such data were the ingredients of this graduate-level/expert user “education”. Yes, their experiences (and knowledge) were shared with others through publications and conference presentations. Also at this time many national geodetic agencies (especially from developing countries) sent selected officers to universities around the world, where they too gained a “GPS Geodesy education” as PhD students.

In the beginning the IGS did not explicitly mention the word “education” in its mission statement. The primary mission of the IGS is (IGSCB, 2004): *“to provide a service to support, through GPS data products, geodetic and geophysical research activities. Cognizant of the immense growth in GPS applications the secondary objective of the IGS is to support a broad spectrum of operational activities performed by governmental or selected commercial organizations. The service also develops the necessary standards/specifications and encourages international adherence to its conventions.”* But, as hinted above, there was an education process, and many of the people who were identified with the IGS (leading academics and researchers) did contribute to educational initiatives.

The primary educational initiatives were specially organised workshops intended to impart some knowledge of the precise “GPS Geodesy” techniques that were applicable for a particular scenario. Hence there were workshops on geodetic network establishment, on how to use GPS for geodynamics, for long-range precise GPS positioning, and so on. And some that tried to address all geodetic applications. It is not possible for me to do justice to all the “GPS Geodesy” educational initiatives that were undertaken, but I will refer to two in order to contrast these with the current *lack* of similar activity.

The 1st International School “GPS for Geodesy”, was held 26 March-1 April 1995, in Delft, The Netherlands. A veritable “who’s who” of geodesists gave lectures that distilled the collective knowledge of “GPS Geodesy”, and indirectly drew attention to the important work of the IGS. The 2nd International School was held 2-8 March 1997. Since then nothing! The concrete outcome of these workshops were the collection of lectures published as Teunissen & Kleusberg (1998), a textbook for “GPS Geodesy”. The tragedy is that this book is no longer available from the online bookstore Amazon.Com! Is there a more recent text or reference book? As far as I am aware, there is none. All of the recent GPS books emphasise applications such as surveying and navigation, and although have the obligatory chapter dealing with the International Terrestrial Reference System (ITRS) and datums, and mention the IGS, none builds on the network-centric techniques first described in Ibid (1998), and since refined even further by the IGS community.

The second example of an educational initiative firmly focussed on “GPS Geodesy” is one in which I played a part as co-organiser and lecturer: the “Tropical School of Geodesy”, the first of which was held 18-29 October 1993 in Bandung, Indonesia. This workshop covered all geodesy topics, including GPS, and was intended for geodetic surveying practitioners in developing countries. The lecturers intended that the workshop would promote the use of modern geodetic techniques. The second School was held 4-16 November 1996, also in Bandung. No further Schools have been held. What happened? Did we just tire of the task? Did we not get as many “kicks” from teaching as before? Or did we believe that it was no longer necessary, that the user was educated enough? Speaking for myself, I favour the last explanation. What if this is a universal attitude? Have the early educators of the 1980s and 1990s just

scaled back such initiatives? Does a new generation need to step forward?

It is more complex than just passing the education role to a new generation of academics and researchers. The target user community has also changed, and the stakes in *not* investing effort into education are now as high (or perhaps higher) than they were in the past. *So perhaps the IGS has to (finally) take a more central role in education.*

According to the new mission statement (IGS, 2002), *“The IGS is committed to providing the highest quality data and products as the standard for GNSS in support of Earth science research, multidisciplinary applications, and education. These activities aim to advance scientific understanding of the Earth system components and their interactions, as well as to facilitate other applications benefiting society.”* The word “education” has now appeared!

3. Should the IGS Be Concerned About Education?

The development of the IGS Strategic Plan 2002-2007 (IGS, 2002) was the catalyst for the change of the Mission Statement. Three of the six identified long-term goals and objectives of the IGS are relevant to this discussion:

1. *Promote universal acceptance of IGS products & conventions as the world standard.*
2. *Continuously innovate by attracting leading-edge expertise & pursuing challenging projects & ideas.*
3. *Seek and implement new growth opportunities while responding to new user needs.*

The first goal clearly would involve the “education” of all users that might benefit from IGS products. Such users are now clearly a wider community than the geodesists/geoscientists of the 1980s and 1990s. The second goal involves more “outreach” than education, however we need not make such a distinction here as the aim is to reach out to the non-traditional user and to engage them in new projects and ideas. Finally, the third goal refers to “new user needs”. In summary, these updated IGS goals and objectives relate, explicitly or implicitly, to a future “new” user community. By implication, a community that is not currently aware of the IGS and its products/services, and hence a user group (or groups) that is (are) outside the traditional “GPS Geodesy” community.

If we follow this “educating the new user” theme further, we note in the IGS Strategic Plan (Ibid, 2002) that the first strategy is to: *Ensure delivery of “world-standard” GPS (& other GNSS) data & products, providing the standards & specifications globally.* Three methods to fulfill this strategy were identified -- they speak for themselves:

1. Maintain & improve accurate, robust and reliable GPS/GNSS data, products, ...
2. Promote IGS data, methods & products to current & potential users as a “world” standard, and broaden the IGS user community into other areas.
 - *Develop broader outreach & education.*
 - *Devote attention to user needs & interfaces...*
 - *Build partnerships – interdisciplinary, suppliers, commercial, intergovernmental, & sponsorships.*
 - *Expand participation.*
3. Attract leading-edge talent for continuous innovation.
 - *Embrace new & innovative project proposals.*
 - *Publicize IGS involvement in novel science, pilot projects, working groups, & other challenging activities.*

While it may be possible to differentiate user “education”, “outreach” and “engagement”, let me not split-hairs. Each of these warrants attention (energy, money, commitment, etc.) that is in addition to that focussed on the primary mission of the IGS, the generation of high quality products and services.

Can the IGS take on such new activities? Who is the target community? What is at stake if it is not done? There are no obvious and/or simple answers, and that is one of the stark lessons to be learned. However, the following *personal* observations can be made:

- There has been little IGS “badging” of education activities in the past.
- Traditional IGS user communities (geodesists and geoscientists), although they are in the best position to adopt new products and services, still need “GPS Geodesy” education.
- New user communities (navigation, engineering, telematics, non-positioning, etc.) is largely ignorant of the IGS, and needs “educating” (in the widest sense).
- There are a variety of ways to address training/education needs, through short courses, symposia, books, etc.
- If the IGS does not embrace new users (through “education” or “outreach”), new products and services may be developed with formal IGS involvement.
- A Global Navigation Satellite System (GNSS) such as GPS is but an enabling technology, and many users do not have an appreciation of the fundamentals of reference frames, etc., nor of the performance constraints due to biases and errors.
- There are other (rival?) organisations apart from the IGS working on developing “standards & specifications” related to GPS products.
- There are many professional or scientific associations, agencies, and even commercial organisations, that have initiated educational activities associated with GPS technology and applications.
- The IAG has recently established an Outreach Branch (IAG, 2004), which has as one of its objectives “education” and “outreach”.
- There are many sister organisations or forums by which the IGS can reach new and old user communities, e.g. through Institute of Navigation, the F.I.G., the U.N. agencies, the C.G.S.I.C., and so on.
- There is (so far) a disturbing lack of interest in raising the profile of the IGS through greater levels of advocacy (even for its traditional user communities) at forums to influence the signal definition for next generation GNSSs, such as Galileo and GPS-III.

Is the IGS ready?

4. What Could Be Done? Some Final Remarks

If the IGS is to take “education” seriously then it should convene a workshop or Working Group to explore strategies and options for “user education”, in an analogous procedure followed when a new IGS product or service is proposed. Education should therefore be taken seriously, and not attempted in a half-hearted fashion.

Here are some actions to consider. An educational initiative that is the least risky is to resurrect the “GPS for Geodesy” workshops. Admittedly these address only the IGS’s traditional user communities, but they have been neglected during the last half decade or so. Updated materials are required. Of course what has to be determined are the operational issues of running workshops, the “who, where, when, etc.”. However, such workshops are surely within the means and expertise of the IGS.

Experience gained in organising and running such workshops would be invaluable if/when the IGS chooses to expand its educational activities beyond this traditional user market.

What about the other user communities? One option would be to partner other organisations that already are active in such communities. For example, team with the F.I.G. to address the education needs of surveyors and engineers for new GNSS techniques, network-RTK, CORS networks, 3D and 4D reference frames, etc. Another example is partnerships with Institutes of Navigation, to educate professional navigators in the use of mixed GPS/GNSS, real-time carrier phase-based positioning, WADGPS, SBAS/GBAS, and so on. Or with the IEEE to educate telematics system developers on reference frames, GNSS trends, CORS and A-GPS techniques, multi-sensor systems, etc.

I would like to conclude this paper with one final comment, if the IGS decides that “education” *is* an important function, *on par* with research activities and geodetic operations, *should there be an appropriate “IGS component” established?*

5. References

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