J. Jpn. Soc. Soil Phys.
土壌の物理性
No. 150, p.5 ～ 6 (2022)

How to approach research — what research in TDR taught me

Clarke TOPP

Developing your Own Frame of Reference is Important

When one begins a research assignment early in their career, the choice is usually dependent on a job description written for the outcome expectations of the employer along with the level of financial compensation available. If it appears that a specific research project might lead to future possibilities, each person is recommended to consider:

- Is this research inspiring to me?
- Do I see additional innovative research possibilities here beyond meeting employer expectations?
- Can I achieve my science aspirations here?

From those considerations you can then develop a sketchy but realistic framework or plan for your personal research satisfaction beyond that of what your employer expects.

My research experience in bringing Time Domain Reflectometry (TDR) from radio frequency communication technology to soil water content measurement will serve as an example of this process. In 1974 two geophysicists, Les Davis and Peter Annan, with considerable TDR experience, realized that TDR had the potential to provide a reliable measure of water content in soil. The research question they put to me, a soil physicist specializing in soil water, was — how do we validate that TDR measures soil water content and with what accuracy? Their challenging question offered many research possibilities, which fitted my hopes perfectly for developing a field method for measuring soil water content. Such a project was also quite acceptable to my employer, Agriculture and Agri-Food Canada (AAFC) Research.

The personal story of this research team is given in Topp et al. (2003). This TDR research project offered numerous dimensions of research possibilities. In soil there are the effects of soil texture which was expected to limit where it was possible to use TDR. We showed, however, that a wide range of soil textures did not cause much deviation from the observed relationship between apparent dielectric constant and volumetric water content. Developing field probes for using TDR became a major research and development opportunity by which our team learned a great deal of valuable information about propagation of radio frequency waves in soil.

Do Not Be Afraid of Mistakes

Although mistakes are unavoidable in innovative research, it is advisable to look for the learning opportunities that can be drawn from a mistaken venture. Good planning is important for avoiding mistakes, but research inevitably involves risk with uncertain outcomes. Often a seemingly undesirable outcome uncovers or stimulates other initiatives that may lead to greater research options. In 1980, Ottawa experienced a relatively dry August and the soil profiles at our field sites with vertical TDR installations showed quite dry profiles in the TDR reading of Sept. 15.

Before the next weekly TDR reading, 35.9 mm of rainfall had occurred. The TDR readings after the rainfall showed discernable wetting fronts at the 20 cm depth.

Although this was not replicated research with valid conclusions, our team considered this to be a significant finding from which to develop subsequent TDR research. When I presented these findings at the 1983 Advances in Infiltration (Topp et al., 1983), I sensed that there was little interest. A colleague at the conference told me that our paper was not suited to that conference — a kind way of telling me I had made a mistake in presenting unsubstantiated research. Being convinced that I had blundered an opportunity to promote TDR effectively to hydrologists, I was pleased to learn that Ian

White, who was in the audience that day, saw the potential in TDR.

Shortly, thereafter he and I arranged for my collaboration with the CSIRO team in Australia which produced important research that broadened the potential for TDR (Topp et al., 2000) and added to the world-wide interest in TDR for measuring soil water content and electrical conductivity then occurring all round the world.

Colleagues are Your Most Valuable Source of Good Ideas

In the 1980s the acceptance of TDR was much slower than I and my team had expected. To help scientists understand TDR, I developed the habit of taking a TDR cable tester and a hand held probe to soil conferences. With a flower pot or a waste can of soil I would invite scientists to my hotel room to show how easily TDR measurements could be made including the calculation of soil water content. Often scientists who had experienced such simple demonstrations would invite me to their laboratory to discuss TDR and show others how TDR works. From Frank Dalton I first learned about using TDR to measure soil electrical conductivity. After some productive collaboration, Frank and I both took that experience in our own directions for additional research, in my case as given in Topp et al. (2000).

In the early 1990s Ty Ferré and I met and discussed a few things and decided we should keep in touch. Later, the University of Waterloo invited me to serve as external examiner of Ty's PhD thesis, which I was pleased to do. Ty became one of my most valued colleagues, as we wrote numerous papers together with Ferré and Topp (2002) being representative.

Concluding Thoughts

Planning for one's own science goals can provide incentives for improved research, which will bring you much gratification especially as you collaborate with colleagues.

Significant research results may also encourage your employer to offer increased funding to continue on your chosen path. Very few researchers can escape some regrettable or unconvincing outcomes but very often more favourable results occur with deeper investigations of the limiting factors. Sharing one's research widely and openly encourages a fertile exchange of ideas, from which arise opportunities for productive research collaboration.

References

Topp, G.C., Davis, J.L. and Chinnick, J.H. (1983): Using TDR water content measurements for infiltration studies, pp. 231–240. In Advances in Infiltration: Proc. of the Natl. Conf. on Advances in Infiltration, Chicago, IL. 12–13 Dec. 1983. ASAE Publ. 11–83. Am. Soc. Agric. Engineers, St. Joseph, MI.

Topp, G.C., Zegelin, S.J. and White, I. (2000): Impacts of the real and imaginary components of relative permittivity on time domain reflectometry measurements in soils. Soil Science Society of America Journal, 64(4): 1244–1252, doi:10.2136/sssaj2000.6441244x

Topp, G.C., Davis, J.L. and Annan, A.P. (2003): The early development of TDR for soil measurements. Vadose Zone Journal, 2: 492–499, doi:10.2136/vzj2003.4920

Ferré, P.A. (Ty) and Topp, G.C. (2002): 3.1.3.4 Time domain reflectometry. In J.H. Dane and G.C. Topp (ed.), Methods of Soil Analysis Part 4 Physical Methods, SSSA Book Series No. 5: 434–446. Soil Sci. Soc. Amer., Madison, WI.