VOCATIONAL ACQUSITION OF STEM TEACHERS IN CERN WORKSHOPS

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ABSTRACT: Louis De Broglie suggested the building of atomic physics laboratory in European Culture Conference that was held on 9th December 1949 in order to provide the previous achievement and dynamism to Europe in the fundamental sciences after the World War II. Isidor Rabi also suggested the building of a regional laboratory in 5th UNESCO Conference which was held in Florence, 1950 in order to develop the international scientific cooperation. Eleven countries decided to establish a European Council for Nuclear Research in Paris, 1951. Establishing treaty was signed by 12 countries in 1953. Approvals from the parliaments of Denmark, France, West Germany, Greece, Italy, Netherlands, Norway, Sweden, Switzerland, UK and Yugoslavia were completed on 29th September 1954, and CERN European Organization for Nuclear Research" was established (CERN, 2016). Today, CERN, having 21 members and 4.000 researchers, is the largest accelerator and research laboratory of the world, and is the center of excellence that provides opportunity to develop numerous technological products as well as many scientific discoveries. Innovations, which facilitate our lives from health to communication, energy to material science, security to food sector in every field, emerge through technological devices and systems such as particle accelerators and detectors that are developed by and used in CERN. There are full-scale experiments which are maintained, renovated or at the construction phase today as always being, or designed for future in CERN that is the biggest international scientific and technologic corporation organization of the world (Ankara University, 2016a). The science of physics goes far beyond Newton and Einstein and the particle physics is the future's scientific field. In particular, the inventions, used in the diagnosis-purposed devices in medicine, indicate a new future. For this reason, our teachers should always upgrade their knowledge and should be ready for educating the 21st Century's students. Turkey officially participated in CERN in 2014, and right after, the teacher Workshops were organized. Totally 229 teachers participated to six workshops that have been held in CERN where 150 Turks at PhD, post-doctorate degrees and executing the research from Turkish and foreign universities worked until today. In this article, the professional knowledge and experience acquisitions of teachers who attended the workshops in CERN laboratories on the base of innovation, entrepreneurship and technology in education, dissemination of knowledge by the teachers to other schools, colleagues, policy-makers and students when they come back to school. The article finalizes what should be done in this field for advance development.

Key words: CERN, multidisciplinary training, in-service training, STEM

SCIENTIFIC RESEARCHES IN CERN LABORATORY

The basic function of CERN is to examine the building blocks of substance and their interactions with each other, to execute the experimental works on this matter, to educate the future's scientists, engineers and qualified workforces, and to develop the technologies necessary in researches. The subject of particle physics is the building blocks of substance and interactions between them. It is necessary to collide the substance with higher energies in order to study the structure of material at very small dimensions. Higher the collision energy, possible to study at smaller dimensions. There are accelerators which the experiments at their own energy limits are executed as well as the particle accelerators allowing for reaching to the highest energies upon completing each other in CERN. CERN becomes a center of attraction for scientists all over the world and associates the people from different countries and cultures. As two countries host for main premises of CERN which is located at Switzerland-France border, then the second campus, which was established later, is located within the France borders. CERN appears as a middle-sized town with the social facilities that are used by more than 4.000 staff and thousands of researchers from other organizations every day. Significant part of CERN employees are the young researchers who execute the PhD studies, and work in informatics area in the industry. Due to dense settlement in the region, the large accelerators in CERN were installed within the tunnels under the ground, and only the zones, where the support buildings that must be on the ground are available within the experiment regions, are added to the CERN premises. For instance, very small part of Large Hadron Collider in 26 km length is available within the CERN premises. The main reason why the tunnels are approximately 100m bottom of ground is to avoid preventing of main flow ways of underground waters and to have the accelerator sit on the sound rock base. The top institution of European Organization for Nuclear Research is a council, formed by the participation of two persons, one representing the political governance and other representing the science from the member countries. Despite of each country is represented by two persons in the council, each country has one voting right. The attention is paid to take the decision by common consent. The Science Board, which acts as the consultant for scientific programs to the

Council, consists of the scientists whom their scientific qualifications are recognized worldwide (Akgun et al., 2014).

Particle Physics

Particle physics is the science of "smallest" which studies the infrastructure of substance and its interactions. The smallest ones, subatomic particles create our world together with living beings, other planets, starts, namely everything in our universe upon coming together. Different dimensions are studied by the different scientific branches. We make our observations with our eyes in mechanical field at the meter level. As the dimension increases, first, we observe other planets in our solar system, other star systems, other galaxies and far fields of universe. We call the branches which are interested in such dimensions as astronomy, astrophysics and cosmology, respectively. Cosmology explains 10^{21}-10^{22} meter levels and uses advanced telescopes and satellites. We see the cell, DNA, electron cloud and atomic nucleus, respectively at the micro level. It is possible to examine the section up to electron with microscopes. The scientific branches, which study the section up to nucleus, are chemistry, biology, solid state physics and nuclear physics, respectively. Atom nucleus is formed by the positively charged protons and uncharged neutrons. The protons and neutrons are formed by the particles, called quark. The scientific branch using the particle accelerators and detectors is called particle physics in order to make observation at this level.

Accelerator Physics

It is necessary to collide the substance at higher energies in order to examine the structure of material at very small dimensions. Higher the collision energy, possible to study at smaller dimensions. The particle accelerators are used for this. Working principle of electrostatic accelerators is based on the passing of charged particles from a fixed potential difference and accelerating them. The simplest electrostatic accelerator is a pair of parallel plate which is connected to two poles of a direct current generator. When the voltage is applied between two plates, the electric field occurs between the plates. The charged particles may be accelerated in this electric field. After discovery of atom nucleus in 1911, Ernest Rutherford thought that the atom nucleus might be split with the accelerated particles. John D. Cockroft and Ernest T. S. Walton, the students of Rutherford, designed a 800kV generator in order to be used in accelerating the proton in 1928. They accelerated the protons up to 400keV energy with the electrostatic accelerator which they produced and hit them to a lithium plate. The accelerated protons split the nucleus of lithium atom and created two helium atom nuclei ($Li^7+p \xrightarrow{yields} {}^4He+{}^4He$). This the first experiment which an atom nucleus is split artificially. American physicist Robert J. Van de Graaff reached to 20MV in 1931. Based on the idea of Swedish physicist Gustaf Ising on using the alternative current in accelerators, Norwegian physicist Rolf Wideroe accelerated the positive ions up to 50keV using 25kV power supply with a linear accelerator that he produced in 1928. In 1947, American physicist Luis Alvarez developed a system which might accelerate the particles at higher frequencies and produced the system, called Drift Tube Linac (DTL). As understood from their names, the circular accelerators, which have the circular shapes and are commonly used today, are cyclotron and synchrotron. The first successful cyclotron was developed by Ernest Lawrence and his student, M. Stanley Livingston in 1931. This cyclotron accelerated the protons up to 80keV using 1.8kV RF generator. The synchrotron enables the particles moving in a circular orbit through the magnetic field. The particles move in a metal tube, called beam tube. The largest and most powerful synchrotron and accelerator today is the Large Hadron Collider in CERN (Akgun et al., 2014).

Detector Physics

In this context, "seeing" the subatomic particles also mean, in fact, to see their traces. Energy (E), momentum (p), charge (q), spin (s) and similar characteristics are measured and recorded in the detectors which is briefly described below.

Cloud Chamber

This detector, which was invented by Wilson in 1911, caused the inventor won the Nobel Prize in 1927. Especially, it was used in the experiments and observations which were made during 1920-1950. Essentially, it is a closed media that includes the excessively saturated alcohol vapor. The charged particles, entering from chamber, release the energy throughout the way that they follow and intensify the alcohol vapor and leave the traces like cloud. The photographs of occurred traces are taken and recorded in order to be examined later. If a magnetic field is applied perpendicular to the entrance direction of particle beam to the chamber, then occurring Lorentz power causes the change of particle direction. Thanks to this, the charge and momentum of particles, which leave the spring-shaped

traces, may be measured. Thanks to this detector, the positron was discovered in 1932, and muon in 1936, and kaon in 1947.

Foam Chamber

This detector, which was discovered by Glaser by early 1950s and was awarded the Nobel Prize in 1960, is a liquid filled cylinder or sphere. The liquid is maintained just below the boiling temperature under the certain pressure; for example, it may turn to liquid hydrogen at 27 K temperature and under 5 atmospheres of pressure. When the particle beam, which the trace will be examined, reaches to the chamber, the pressure is dropped immediately and the liquid is heated. The charged particles in the particle beam lose their energy via ionization. This vaporizes the instable liquid and creates the bubble nuclei. The photographs are taken within 1 or 2 microseconds. More than one camera may take the photograph from different angles and may reduce the position resolution by 10 microns. It may be built larger than cloud chamber and since it includes denser liquid, it may detect the particles with higher energy. The weak uncharged currents were found with BEBC and Gargamelle detectors which run with this principle in CERN.

Accelerator Experiments

ATLAS experiment (A Toroidal LHC ApparatuS), which Turkey also participated in, is one of six experiments that were started to perform in CERN on 10th September 2008 and were performed in LHC accelerator. ATLAS and CMS are general purpose, LHCb is about b-physics, LHCf experiment on astroparticles (cosmic beam) physics, Alice on heavy ion physics and Totem on measurement of total effect section.

When the proton beams are collided in the experiment, many fundamental particles occur at the different energies. ATLAS experiment is designed general purpose so that it will measure the traces, energies and momentums of many particles which have been observed or not until today. The collision energy of LHC, 14 TeV and radius, 10^{34} p/cm²/s are the characteristics which were not obtained in the previous experiments. These difficult circumstances make ATLAS experiment the largest and most complex experiment among the particle physic experiments that have been performed until today. ATLAS experiment passes into history as one of two LHC experiments which Higgs Boson was observed along with CMS on July 2012. The researchers are currently carried out in order to collect the meaningful data about super symmetric particles (CERN, 2016).

Neutrino and Higgs Boson

There are three radioactive radiation; alpha, beta and gamma. As the instable nuclei release their excessive charges on them and turn to the stable status, they disintegrate. Alpha disintegration occurs, when any radioactive instable nucleus releases the alpha particle (in fact, helium nucleus with higher energy) and turns to a stable nucleus. In this conversion, there are two units of reduction in atomic number and four units in the mass number. The example is turning of radium to polonium: $Ra^{222} \rightarrow Po^{218} + \alpha$. In gamma disintegration, if γ, then some radioactive nuclei don't release all energies during alpha and beta disintegrations and maintain their higher energy status. They release the gamma radiation in order to turn to the stable status. In this case, there is not any change in the atomic number and mass number of the atom. Beta disintegration means the case where the instable nuclei turn to the stable status through releasing beta particle, namely electron. During this conversion, no change occurs in the atomic number of atom, but there will be 1 unit of reduction in the mass number. By early 1900's, the example for known disintegration was turning of carbon nucleus to nitrogen: $C^{14} \rightarrow N^{14} + \beta$.

Neutrino was first discovered by Wolfgang Pauli in 1930; it occurred in the nucleus and as a result, was prescribed to meet the law of conservation of mass, law of conservation of momentum and law of conservation of angular momentum in beta disintegration where 1 electron, 1 proton and 1 anti-neutrino were released ($n^0=p^+ + e^- + \sim\nu_e$). Pauli stated theoretically that an undetected particle bears the energy, momentum and angular momentum differences between the inputs and outputs, and called this estimated particle as *neutron*. However, after James Chadwick discovered a particle which its mass was larger in 1932 and when he also called it as neutron, Enrico Fermi, who produced the theory on beta disintegration, eliminated this confusion by calling this particle which its mass was smaller as *neutrino* that means *smaller neutron* in Italian. Neutrino is one of the fundamental particles which has almost light speed, electrical charge is zero and passes throughout the materials almost without interaction. These characteristics make the detection of neutrinos quite difficult to be detected. Neutrinos, which are denoted with ν (nu) letter in Greek alphabet, have very small masses, but not zero. Neutrinos resemble the electrons, except not having the electrical charge. Since the neutrinos are non-charged electrically, they are affected by the electromagnetic forces. Neutrinos are only affected by the 'weak' force which its distance is very smaller than electromagnetic force; for this reason, they may pass through the materials almost without interaction. Since

the neutrinos have the mass, they interact with gravitation same as other particles with mass; however, the gravitation is the weakest one among known four forces. Neutrinos occur in the certain atom disintegrations or in the sun, nuclear reactors or as a result of nuclear reactions, when the cosmic beams collide with the atoms. There are three types of neutrino: electron neutrino, muon neutrino and tau neutrino. Each type of neutrino has one particle, called anti-neutrino. Electron neutrino (or anti-electron neutrino) occurs, when proton turns to neutron or vice-verse – two forms of beta disintegration. Interactions, including the neutrino, are the systems created by the weak force. Most of neutrinos released by sun reach to the Earth. Approximately 65 billion neutrinos reach to cm^2 of Earth perpendicular to sun per second (ATLAS Group, 2012).

The mass, which Newton defined as amount of matter and is the resistance of material to the acceleration, is an attribution which determines the amount of gravitation between it and other materials. According to Einstein, the mass gives the energy amount which corresponds to the stable material. The mass of proton is 938, 3 MeV. Total mass of u + u + d quarks that form proton is 9, 4 MeV and is a small part of proton mass. Remaining 928, 9 MeV of mass is the kinetic energy of quarks and gluons in the proton. The attribute of these quarks is mass, namely the mass which fundamental particles gain through Higgs operation. According to Higgs theory, there is a Higgs field at every single point of universe. Field is a fact which has a value at every point of space-time. This field may be assumed as a magnetic field that allows the magnets pull or push each other, or forms the iron dust around the magnet. The fundamental particles gain the mass interacting with this Higgs area. Neutrinos, which area created in the Large Hadron collider and disintegrate within microsecond, create the Higgs field which enables the material gain the mass.

PARTICIPATION OF TURKEY IN CERN

Turkey's relation with CERN has been coordinated by TUBİTAK during 1961- 2015, and from 2006, it was assumed by Turkish Atomic Energy Authority (TAEK, 2016). The cooperation agreement was signed between TAEK and CERN on 14th April 2008, and the preparations of official application by Turkey for CERN membership were accelerated and the application was filed on 18th May 2009. The application and works of Turkey related to CERN membership were discussed during the CERN Council meeting, held on 17th December 2010 and were considered positive. The application by Turkey related to member associate was filed via Government letter, dated 17th October 2012 to CERN and this application was accepted in the CERN Council meeting, dated 13th December 2012. After the mutual negotiations and evaluations between Turkey and CERN, CERN Council accepted Turkey's application related to member associate with its decree, dated 20th March 2014. The agreement on membership associate between Turkey and CERN was signed by CERN director, Prof. Dr. Rolf HEUER and Turkey's UN Geneva Permanent Delegate, Ambassador Mehmet Ferden ÇARIKÇI and the Minister of Energy, Taner YILDIZ on 12th May 2014. The agreement was approved by common consent in the General Board of Turkish Grand National Assembly, dated 22nd January 2015 which TAEK was also represented.

The primary provisions of this agreement, which was signed in a period when works and investments related to common and effective using of particle accelerator and detector technologies (Turkish Accelerator Center, etc.) also increased in our country, are given below in summary: Turkey accepts the legal infrastructure, operation rules, regulations of CERN and the decisions which are taken by its organs through agreement. Turkey shall affect minimum one tenth (1/10) of the full membership contribution (membership fee) which is calculated according to the economic size and population, provided that it shall not be less than 1 Million CHF. Turkey, which participates in education and training programs of CERN as well as in scientific research programs, has the right to be represented in CERN Council (except the closed sessions) without voting right and may begin to speak and give representation without expecting any invitation. Turkey has the right to be represented in the meetings of CERN Finance Commission. Scientific representative of Turkey in Council may attend the CERN's Science Policies Meetings as an observer. The citizens of Republic of Turkey may apply for CERN personnel assignments to the academic memberships, studentship and faculty memberships through the limited and periodical contracts. Firms, which offer the Turkish origin goods and services, may submit the bid to the CERN contracts based on the Regulation on Implementation of CERN Financial Rules. Turkey may assign an industry contact officer in CERN. The compound financial amount of works to be carried out by Turkish firms in CERN shall not exceed the financial contribution to be made by Turkey to CERN within the scope of agreement in no case. Turkey may turn from common membership associate status that is gained through this agreement into the membership associate status as a pre-phase of full membership and then, full membership status in CERN.

Keep Calm and Focus on CERN Projects

There has been an intense interest and curiosity about the CERN laboratory, its accelerator and particle physics due to the discovery of the Higgs particle. This interest is not misplaced, because particle physics and accelerator

technology are very active and colorful disciplines, which live on constant innovation and which push the limits of science and technology. It is very important and useful for students, teenagers and everyone who carries the excitement of discovery inside them to get to know to this field aimed at finding the most basic building blocks of the Universe (CERN Project, 2016). So, Keep Calm Project is developed with the following expected results;

- Learning of the basic concepts of particle physics and elimination of misconceptions
- Learning of the ways of scientific knowledge
- Achievement of a positive attitude towards science
- Gain of some minimal experience with using basic software in this field
- Creation of a web site and virtual classrooms
- An increased capability to provide scientific explanations for natural phenomena
- Increased knowledge of applications on basic sciences (math., physics, chemistry)
- Better comprehension of the scientific method and research skills
- Increase in students' verbal and written communication skills
- Capability of directly associating gained knowledge with technology and industry;
- An enhanced vision for application areas
- Development of insight based on basic concepts rather than details
- Learning how to describe an experimental study

The project tools which may be used by the trainees are the followings (Akgun et. al., 2014);

- To create an atom model by using http://sourceforge.net/projects/jmol/ Periodic table application
- Physical activities simulator by STEP
- For supporting the CERN experiments from GRID computing system
- http://boinc.berkeley.edu/
- To prepare online questions by kahoot.it
- To create websites: https://tr.wordpress.org/
- Sharing of studies and research papers with Twin space
- Information meetings with e-twinning portal and e-conference system of science trip
- How to adding activity photos to the Prezi presentation tool
- e-conferences: e-twinning portal and e-conference system of science trip
- How to use Voki, Padlet, Canva or Postermywall, Littlebird Tales, eTwinning Live,
- Modelling with sketch up, weebly /edmodoo, Kahoot.it

BeaLine Project Contests

The incoming proton beam from the PS accelerator impinges on the North target and thus produces the particles for the T9 beam line. The collisions of the protons with the target can provide a variety of particles, such as electrons, positrons, muons, pions, kaons and (anti-)protons. The T9 beam line may be used on different projects. The participation should be provided in "BeamLine" Project contests held in CERN with talented and enthusiastic students (Beamline, 2016). The student projects, which were participated in this contest previously and were awarded the prize, may be delivered to Turkish and foreign teachers whom it may be communicated with in order to prepare a new project (Beamline, 2016). It is possible to access to the experiment fields and use the possibilities through internet (CERN, 2013).

CONTENT OF CERN TEACHER WORKSHOPS

The professors and subjects of workshops organized by Turkish Scientists in CERN is given below. The content of five-day workshops is as follows;

- About CERN and expectations, Prof. Dr. Samim Erhan, University of California Los Angeles
- Particle Physics, Prof. Dr. Bora Akgün, Rice University
- Detector Physics, Prof. Dr. Saime Gürbüz, Boğaziçi University
- Astroparticle Physics, Prof. Dr. Cenk Yıldız, University of California Irvine
- Accelerator Physics, Prof. Dr. Veliko Atanasov Dimov, Boğaziçi University
- Neutrino Physics, Dr. Umut Köse, Padova University, INFN
- About Higgs, Prof. Dr. Sezen Sekmen, CERN
- BL4S 25', Prof. Dr. Saime Gürbüz, Boğaziçi University
- Show with Computer, Prof. Dr. Gokhan Unel, University of California Irvine
- Detector Workshop @UBS (2Cloud chamber & electron tube)

- Detector Workshop group "muon" and "antimuon", Prof. Dr. Saime Gürbüz, Boğaziçi University
- AD and Data Center, SM18 and CAST, ATLAS and SC, AMS & CCC tours

CRITERIA FOR SELECTING CERN WORKSHOP TEACHERS

The teachers, who will attend the workshop, are evaluated and determined by Turkish scientists in CERN, MEB official and the teachers who attended the CERN workshops previously through a form which they will complete according to the below criteria**.** The number of applicant teacher increases gradually upon more recognizing and knowing the CERN Workshops**.** 36 teachers were selected among 750 teachers who applied for Sixth Workshop.

- Those who have the higher learning, researching and knowledge sharing desires,
- Those who are able to show that they really follow the scientific developments in particle physics with the contents of their questions,
- Those who are experienced, effective in education life, attend the training, and direct their students toward the contests,
- Those who are at the beginning of their work lives and may evaluate the investment for a long-time
- Those who declare that they give seminar to the public by travelling to surrounding provinces and counties, not only to the students,
- Those who may collect the sufficient experience during their work lives and may affect and direct their young colleagues,
- Those who may address toward large masses through electronic or similar medias,
- Those who may inform the students and society rather than providing their personal academic development with what they learn in CERN,

PROFESSIONAL GAINS OF TEACHERS THROUGH CERN WORKSHOPS

As total 6513 teachers from member and candidate countries attended the CERN Workshops during 1998-2013, only 3 teachers from Turkey attended such Workshops. From 2014, the distribution of 229 teachers, who attended the CERN Workshops with the significant initiatives from Turkish Team of CERN according to the provinces, is given in Figure 1.

Figure 1: Distribution of 229 Teachers attended the CERN Workshops according to the provinces (Teacher Training Programs, 2016)

The survey was carried out in our teachers who attended the CERN Workshops (Workshop Teacher Survey 2016). Primary gains of the teachers may be summarized as follows;

- Teachers obtained the significant scientific gains and encouragements related to their profession by visiting CERN which was the most important laboratory of world.
- Their views about education, research, profession and world changed significantly.
- Peer learning started. It is provided the accession of them to many scientific communities in the country and abroad.
- Our teachers, who attended the workshop (CERN Workshop, 2016), shared their knowledge and experiences giving many conferences and making presentations upon returning, notably in their schools and provinces.

- For the first time, they went abroad for education through Ministry of National Education official and financial support which highly motivated them.
- They met their colleagues in their schools and abroad and obtained information about their works.
- They observed the implementation of theoretical knowledge practically and implementation of research results to the industry.
- They remembered to update their knowledge and need of making research,
- It opened a road to similar laboratory visits and Workshops for our teachers in the Ministry.
- They gained moral and encouragement understanding that the Ministry valued them.
- They knew many websites and portals, and began to establish the similar websites and portals.
- They knew to contribute to spreading of knowledge giving conferences in their schools and other schools when coming back, and network establishing process started in the country.
- They gained the ability of using e-conference system, and enhanced their presentation skill.
- The awareness increased about the subject today when the accelerator technologies developed and the works on establishing the centers were currently carried out in Turkey.

CONCLUSION AND RECOMMENDATIONS

The following conclusions and recommendations are developed analyzing the poles that are made to 138 teachers who attend the Workshops, face-to-face interviews with them and observations of CERN researchers at the end of Workshops which have been repeated six times until today;

- As seen from the above developments, the science of physics develops based on the discoveries of Newton and Einstein, but in a speed much far beyond them. If our teachers, whom the subjects which they know and tell are available as the very qualified visuals in the websites that the students may access, don't refresh their knowledge permanently with the new information and discoveries, then they will face with the fact of professional death. For this reason, CERN Workshops, which we consider them very important, must be organized in other scientific fields also.
- It is observed that the workshops and educations are very beneficial, and should be maintained. 5-day preparation should be made before attending the CERN Workshop in Turkey. The workshops at higher levels may be organized for our teachers who attended the workshop one year before. For this purpose, the cooperation may be established with TAEK and Ankara University Institute of Accelerator Technologies.
- The workshop period should be minimum 10 days and more number of experiments should be performed. CERN Scientists should organize e-conference to the CERN teachers in certain periods.
- The participation from science high schools, which their number reaches to 500, and from provinces, where no participation was obtained previously, should be encouraged and proliferation should be provided.
- MEB should support the undergraduate education of CERN teachers (Ankara University, 2016b).
- List of teachers, who will attend the workshop, should be issued not more than 3 months before the workshop date.
- The content of program, addressing to the teachers and students of high school and secondary school, should be differentiated.
- The projects should be prepared which will introduce CERN and particle physics and will direct the scientific productivity, and the science fairs should be organized within the scope of TUBİTAK4006 Program.
- The cooperation should be established with Ministry of National Education, TUBİTAK Science Centers, TUBİTAK Science and Society Department, TAEK and Ankara University Institute of Accelerator Technologies.
- http//keepcalmandfocusoncernprojects.weebly.com/project should be proliferated.
- The faculty members and teacher candidates from faculty of education in the universities should attend.
- Networking work should be carried out between teachers from other countries who attend the Workshops and our teachers.

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