A FLEXIBLE LIFE LONG LEARNING TOOLBOX FOR CHEMISTS

VOCATIONAL AND UNIVERSITY EDUCATION WITH MOBILITY ELEMENTS

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Abstract — *The present paper gives an overview on good practice examples in different European countries taking into account the Bologna process. The sector of chemistry is chosen as the field described because of its particularly advanced and flexible educational structure. The advantages, disadvantages and the benefits are discussed. Good practice in this sector may well serve as a model for other sectors.*

Key words — *chemistry, career paths, life long learning, mobility, placements*

INTRODUCTION

At the Lisbon European Council in March 2000, government leaders set the EU a 10-year mission to become the most competitive and dynamic knowledge-based economy in the world, capable of sustained economic growth with more and better jobs and greater social cohesion. Lifelong learning is a core element of this strategy. Life-long learning encompasses learning for civic and social purposes as well as for the employment-related ones. It includes all forms of learning such as, formal learning (degrees), non-formal learning (vocational skills acquired within the workplace) and informal-learning. Life long learning requires that learning outcomes from different settings and contexts can be linked together [1].

In the sector of chemistry, there is a long tradition of various forms of education at different levels. Apart from country-specific forms, there are some features which are common to many countries. In the framework of the Bologna process educational reforms, the sector's traditions are being developed further. This paper gives an overview of some important developments, in an attempt to foster European co-operation, mobility of students and dissemination of good practice. Special emphasis is given to permeability (mobility across educational level barriers) and transnational mobility, to placement during education and to employability aspects. Some of them are covered in the White Book of the Forum for Advancing Chemical Education, FACE, product of a LEONARDO project [2].

TOOLS IN THE BOLOGNA PROCESS

The diversity of different national traditions and approaches to education in Europe is a wealth because it allows alternatives and sharing of strengths. It can be a burden if diversity gives rise to hurdles and obstacles for mobility. In the past 15 years, tools have been developed which help to avoid such obstacles.

The European Quality Framework EQF [3] and the Dublin descriptors [4] classify levels of education based on learning outcomes and competences. Study programmes described in terms of EQF and the descriptors can be compared properly.

The European Credit Transfer System ECTS [5] based on student workload is an approach to a quantitative description of courses for trans-national exchange, helping to "carry" coursework results from one country to another, and within countries. Together with a grading scale for student performance, it is documented in the course reports. ECTS is currently developed further to have an equivalent in the vocational education sector; this is called ECVET [6].

Each mobile student should have a Europass and use the European CV for applications [7].

The Diploma Supplement [8] and Certificate Supplement [9] are documents to be handed out to each student, giving comprehensive information about the national education system from which it comes, about the relative position of the course in the national and European contexts, and about specific achievement of a given student, including mobility, placements, social and personal skills and extra-curricular activities.

With the Eurobachelor® and Euromaster® [10], the European Chemistry Thematic Network Association, ECTN, has developed a quality label for chemistry higher education. Courses which bear these labels after an accreditation procedure fulfil the quality requirements of these labels, including minimum curricular demands, and make such chemistry courses comparable on a European level.

NEEDS OF THE CHEMISTRY SECTOR

The specific needs of universities and employers in general and specifically those of the chemistry sector have been described from different points of view. Important aspects are [11] the following:

- We need an easily understood framework of chemistry qualifications which embraces the range from technician level awards through to vocational Masters degree and short courses of adult training, including the definition of multiple entry, exit and re-entry points – with appropriate certification
- We need technical staff with vocational training including not only knowledge but also social, international and problem solving competencies,

ideally having been trained to tackle complex tasks in a result-oriented manner

- We need university graduates with soft skills and with job relevant experience and skills alongside with their chemistry knowledge and hence better co-operation between industry and university with active participation of both partners.
- We need practical (industrial) work periods as a good opportunity for the future university graduate to realise which knowledge and skills play a role beyond the classical technical/chemical subjects traditionally taught in the academic world.
- We need careers guidance about the relevance of course choices for future employment prospects.

In 2004, the social partners in the sector,

- European Chemical Employers Group, ECEG, affiliated to European Chemical Industry Council CEFIC, and
- European Mine, Chemical and Energy Workers` Federation EMCEF

issued a joint position paper [12] and formed a working group on labour force, life long learning and employment aspects. They discuss these aspects in the social dialogue. The paper sets the goals for this dialogue:

"ECEG and EMCEF are both convinced that vocational training, regularly and appropriate further training and life-long learning over the entire working life is essential, not only for companies in order to maintain successful, productive and efficient, but also for each employee in order to maintain his or her employability. Employers within the European chemical industry therefore have a strong interest in offering opportunities for their employees for an initial as well as further vocational training in accordance with the requirements of the specific jobs dealt with by the employees and to motivate employees to participate in this training. Employees within the European chemical industry have the same strong interest in looking after their individual vocational skills and in investing in these qualifications in order to keep their employability at the highest possible level."

The social partners specify that they want to work on

- "a more in-depth analysis of the *status quo* regarding skills, qualifications, vocational (further) training and lifelong learning within the industry;
- an exchange of information and good practice of the different national systems of education, vocational (further) training and lifelong learning in order to support the further development in these areas."

The basis for this discussion is the structure of chemical education in Europe at all its levels. A brief summary of the various levels and forms of education will help to classify them properly.

LEVELS AND FORMS OF CHEMICAL EDUCATION IN EUROPE [2]

Forms of chemical education in Europe can be described as a "career ladder", comprising different offers (not all of which are used in each European country). It starts with **vocational education**, such as

- "dual" education courses including periods or days spent in a school and in a company; a specific form of which is multifirm training shops (Germany)
- School-based secondary education courses (e.g. CTA in Germany, foundation courses in the UK, CFM in Spain)
- Post-secondary, non-tertiary education (e.g. Kolleg in Austria, CFS in Spain)
- Combinations of General and Vocational Education leading to A-level examinations (HTL in Austria, Czech Republic and Hungary)

Tertiary education has undergone major changes in the Bologna process. A large variety of university courses with a broad spectrum of profiles are found, including

- 6 semester Bachelor courses (throughout Europe)
- 7 semester Bachelor courses, mostly including a placement semester (mainly in Germany)
- 8 semester Bachelor courses (e.g. in Spain, Bulgaria), including a placement year (UK) or a placement semester (one example in Germany)
- Some of the aforementioned courses may bear the Eurobachelor label [10]
- Consecutive and non-consecutive Master courses of 2, 3 or 4 semesters, including courses bearing the Euromaster label [10]
- Doctoral degrees, some of which include taught parts and some of which may be done in co-operation with industry
- Continuing professional development courses (CPD), including formal and compulsory CPD (e.g. in the UK)

If the tools which where briefly presented above are used in the development and description of education programmes at all levels and in all countries, the mobility of learners between different levels of education (permeability, individual career) and between different countries (horizontal/vertical mobility, learning and studying abroad, placements) are facilitated. The vision of a "House of chemical education" [2, chapter 7] will thus come true step by step.

The two types of mobility will now be briefly described and their benefits will be discussed.

PERMEABILITY – PRE-REQUISITE FOR LIFE LONG LEARNING

"Flexibility in terms of course structures, admissions, recognition of prior learning as well as prior experiential learning is essential", and "The European Qualifications Framework for lifelong learning (EQF) approved by the EU institutions in April 2008 covers both higher education and VET and aims to facilitate movement between the two" [1]. There are various approaches to a credit system for VET (vocational educational training) which allow the student to pass on from one degree to a "higher" one without having to start from scratch [6].

Hochschule Fresenius, a private University of Applied Sciences, developed from the first vocational training institution for chemistry founded in 1848 by C.R. Fresenius, a PhD student of J. von Liebig. Until 1930, the vocational training this institution offered was based on its own, practically oriented curriculum. Then it became a state-recognised course for "Chemotechniker" (Chemical Technicians), which in the 60's of the last century gradually developed into a tertiary education course "Chemieingenieur". In 1985, a two-year vocational training course started which leads to the degree of "Chemisch-technischer Assistent (CTA)", comparable to a UK Foundation Degree. The rare feature of having VET and Higher Education (HE) courses in one institution facilitated the development of a permeability scheme.

What are elements of a successful permeability policy in a Higher (and Secondary) Education institution?

- An institutional policy that defines permeability as a core element of all activities, from curriculum development in HE and VET, to implementation of curricula, taking into account in each case the needs of the other level of education
- A clear framework of transparent but still flexible regulations, as a part of the examination regulations and approved by the relevant government bodies of the Federal State of Hessen, both on the HE and VET side.
- A framework of regulations which facilitates permeability removing unnecessary obstacles, but at the same time guaranteeing the quality of the degrees awarded.
- Guaranteed ways of recognition of prior learning, provided it is properly documented.
- Individual tutoring and coaching of students who wish to progress to the next level of education.
- Bridging courses, if needed, to help students fill gaps which they may have, before entering the next level.

Thus, students having completed a vocational training of the dual or of the school-based type (see above, for a detailed description of VET courses in various European countries, among them Germany and Austria, see [2]) are admitted to a higher semester of the HE course (Bachelor) in chemistry, depending on their prior learning and individual performance (good grades, specified in an appropriate Hochschule Fresenius guideline). Students of the CTA-course who may enter the school with an O-level examination (Realschulabschluss) are offered a course leading to Fachhochschulreife (an advanced certificate opening the way to HE which in these cases replaces the A-level exam – Abitur (Germany) or Matura (Austria). The regular way for CTA is entering the second year of the Bachelor course. Since 1997, the HE chemistry course of Hochschule Fresenius is also open for graduates of the Austrian Kolleg and Höhere Technische Lehranstalt, HTL. Like graduates of the German Techniker (CT-) course, they may enter semester 4 or semester 5 of a 6- or 8-semester Bachelor course of Hochschule Fresenius (these Bachelor courses are described in detail by Gros, [13]).

In the past 25 years, this specific career scheme has been developed further and adapted to the needs of new generations of young chemists. Hundreds of students benefitted from it, saving time and money, and making their individual career, which led some of them up to a PhD degree. Two examples are shown in the section "Anecdotal Feedback" below.

TRANSNATIONAL MOBILITY – INTERCULTURAL EXPERIENCE AND PERSONAL MATURING

In an HIS-survey, interviewers found that 55% of the companies employing engineers (scientists) want proficiency in the English language. 14 % want at least two foreign languages spoken by graduates. 44% of the graduates interviewed said they needed special foreign language proficiency in their job. More than 25% of all job offers in this sector include statements about work abroad, 20 % speak of the need to travel internationally; 20 % of the graduates working in the sector say they have to travel abroad [14]. Hence, there is more than one reason to foster trans-national (horizontal) mobility of students! Students themselves report that they have gained personal experience – experience about themselves. They consider this as an important part of their personal maturing. Individual case studies are documented below (Anecdotal feedback).

Hochschule Fresenius has a 15-year record of development of a successful foreign placement policy in the sector of chemistry, including both HE and VET levels. 50-70 % of the University of Applied Sciences students of the past 12 years have gone abroad for at least one semester, and a smaller number of VET students went abroad for 4-6 weeks. In the new Bachelor and Master courses, mobility is an important part of the programmes. In the 8-semester International Bachelor of Applied Chemistry, one semester abroad is compulsory.

What are elements of a successful horizontal mobility policy in a Higher and Secondary Education institution?

- An institutional policy that defines mobility as a core element of all activities, from curriculum development to diploma/certificate supplement and from consulting of possible applicants to tutoring of outgoing students
- A clear framework of regulations, recognised by the relevant government bodies of the Federal State of Hessen (which took part in the development from the first day on!)
- Guaranteed ways of recognition of periods spent abroad
- A network of 50 companies and universities helping to find the proper placement company and country for each individual (University Network with Industry in Chemistry, UNIC)
- Sponsorship by EU LEONARDO DA VINCI grants doing away with most of the financial obstacles
- Tutoring of work experience abroad by staff of EFF visiting the students abroad during a 5 month placement – travel expenses being in part own funds in placement projects. In rarer cases, colleagues of partner universities in the foreign country do the tutoring.
- Motivation by teaching staff and by fellow students coming back home and being enthusiastic about their experience

A comprehensive review of so called "alternating forms of education" including a placement period is given by Cooke et al. [2], where benefits and learning outcomes of students are also discussed from the university, employer and student points of view.

INDUSTRIAL PLACEMENT EXPERIENCE – AN ASSET FOR EMPLOYABILITY

In a recent survey [15], the European Chemistry Thematic Network (ECTN) studied the employability of Bachelor graduates. Together with other studies in the past 10 years, it gives clear evidence that employability of graduates is positively influenced, and greatly enhanced, by industrial placement experience of appropriate duration (in general at least 5 months in a Bachelor or Master course). Industrial placement and international experience can be combined when students complete a placement abroad.

Companies complain that students without placement experience often do not know hierarchies in industry and that they are not familiar with everyday job life. They lack an understanding of cost and benefit as well as time constraints and sometimes have little idea of quality control aspects. These things are best learned in the "natural environment" of a company.

Different types of placement periods and of their appropriate organisation and evaluation are discussed in a recent publication. It also discusses learning outcomes and benefits, including employability. According to these authors and the sources they discuss, important learning outcomes are [16]:

Oral communication	Frequent discussions with work supervisor and work colleagues, both face to face and by telephone
Written communication	Written reports often required by employer; university may require reports; written communication by e-mail to work colleagues
Language skills	In case of placements abroad: both oral and written communication skills in a foreign language
Teamwork	Requirement to work collaboratively with others, often from different backgrounds; sensitivity to the needs and feelings of others.
Numeracy	Increasing awareness of significance of numerical results, of accuracy, source of errors and of units of measurement.
Taking responsibility	Taking "ownership" of experimental results; being accountable to others; development of authoritative role
Disciplined working	Need to attend punctually and to meet the demands of the job; need to conform to the rules of the workplace including all aspects of health and safety.
Self organisation	Planning of tasks to make best use of time and resources;
Adaptability and flexibility	Making the transition from an academic environment; living away from home; encountering different cultures; being self sufficient.
IT and computing	Word processing; need to process results e.g. with spreadsheets; use of databases; computer control of instruments; computer aided visual presentations; e-mail
Networking	Seeking out of others in different departments in order to perform tasks and gain information; potential interface with company clients
Showing Initiative	Proposing a better way of doing things; foreseeing tasks that need to be performed; making suggestions for health and safety.
Gaining confidence	Being able to perform to a good standard; receiving praise and encouragement from supervisor
Career planning	Appraisal of career opportunities within or outside the organisation through liaison with others.
Environmental	Critical appraisal of waste disposal

awareness and recycling processes

This publication also gives evidence that performance of mobile students during studies is better than that of their peers who do not leave their country, and that employability is enhanced by a properly documented mobility period.

MOBILITY PAYS: ANECDOTAL FEEDBACK FROM THREE ALUMNI

Finally, we let students speak who graduated from programs offering vertical and horizontal transnational mobility chances. Like these, more statements of alumni are found in [2], chapter 4, and at the Hochschule Fresenius homepage www.hs-fresenius.de.

Let us start with a student using both – Kai. "My name is Kai Hoettges. After my O-level examination in Germany, I initially qualified as CTA (Vocational Training, Chemisch Technischer Assistent), at the VET branch of Hochschule Fresenius. During that time, I took part in additional courses of General Education. This and my good results in the CTA examination opened me a way into the third semester of the Chemical Engineering degree studies (Dipl. Ing. Chem., Univ. of Applied Sciences), which is the HE course at Hochschule Fresenius. This is an example of transferability of secondary VET school credits to tertiary level.

During my studies I spent my placement semester in Sheffield, UK (with a LEONARDO grant) and did research for my diploma thesis at Royal Holloway University of London, UK. In both cases I developed large volume injection methods for gas chromatography under the supervision of Prof. Michael Cooke. Contacts gained during this time allowed me to secure a place for my PhD studies at the University of Surrey, where I studied lab-on-a-chip devices. The project let to a patent application for a miniaturised liquid-liquid separator. After my PhD I worked as a postdoctoral researcher on several projects (including a four month Marie Currie fellowship in Bologna), investigating the applications of dielectrophoresis to enhance the detection of bacteria, to separate carbon nanotubes and to characterise cells. This work led to further three patent applications. I then started a spin off company to commercialise the results of my research in high throughput cell characterisation. I live in the UK with my Italian wife."

Jörg also used both types of mobility, but opted for an industry career: "My name is Jörg Heisiep. I studied Chemical Engineering at EFF Hochschule Fresenius in Idstein. I did my practical work placement between 1st Sept 2000 and 31st January 2001 in the UK.

Since 1988 I had studied at Hochschule Fresenius VET school to become a chemical technical assistant. Because of my good results I was given a chance – after an entry examination – to enter year two of the Chemical Engineering course at the same institution. A work placement abroad is one of the additional activities for acquiring the additional distinction "European Studies" on the diploma. Because English is so important for our area of studies, I chose an English speaking country. As I am especially interested in analytical chemistry, I decided to go to Bioanalytical Services Ltd, a small enterprise which offers services in bio-analytical chemistry…..

My task was to widen the possibilities of the spectra in an HPLC-MS/MS Pesticide data base and to check its usability in the laboratory routine. ….The highly complex task required an initiating phase with a lot of initiative on my part and special support from the person looking after myself. We discussed the various questions of the project in meaningful periods. A second person introduced me to the routine works of the company. The company also helped me with finding accommodation and with job relevant questions.

I had acquired the scientific background during my studies and it turned out that I already had the necessary practical and theoretical requirements to understand my task in the company. The person responsible for me at EFF Fresenius supported me additionally with extra knowledge. He also came to see me in Egham to inform himself about my scientific progress.

Naturally, it is difficult to understand foreign structures and habits, but this is the ingredient which makes a stay abroad interesting, makes you sensitive and broadens your horizon. A work placement abroad should be obligatory. Besides the scientific work, a talent to get yourself organised, to succeed in a team and to cooperate with your team mates plus tolerance is of importance. These are the key qualifications for your future life in a job.

I did my thesis work at Merck, Darmstadt (D). One reason why they gave me the task was that my time in the UK had prepared me for the special and complex analytical technique I had to use. This thesis work was again one key to employment in the same company. I work in the central service lab for analyses and mainly do GC-MS, HPLC-MS and HPLC-NMR, including high throughput analysis. Together with my studies in the university, my work placement was an excellent start for what I do now."

In the meantime, Joerg joined Sanofi Aventis where he is a quality control manager.

Heidelinde gained her prior experience in a foreign institution, Höhere Bundes-Lehr-und Versuchsanstalt für Chemische Industrie, HBLVA, in Vienna. In 2004 she writes: „My name is Heidelinde Dietrich. In 1999, I finished my post-secondary, non-tertiary vocational training at the Kolleg für Chemie, HBLVA Rosensteingasse Vienna, Austria. In the framework of a partnership of this school with Hochschule Fresenius Idstein, Germany, I had a chance to qualify (entrance examination) for the third year of Fachhochschule studies.

The first half of this third year (regular 5th semester of studies) is a compulsory placement semester (5 months minimum) in industry. With the help of a Leonardo da Vinci grant, I could spend this semester at TNO

Voeding in Zeist, The Netherlands. I liked the work and the country and came back for a final year project with thesis. In both cases, I worked in the Department for Chemical and Biochemical Sensors. I developed a coating for biosensors based on S-layer proteins. Such sensors can measure noxious mycotoxins in food. I could work in a team and learn to apply many biochemical techniques. I had a chance to work with BIACORER Upgrade, a device for determining interactions between proteins on one hand and proteins or other molecules on the other hand. My time with TNO proved to be very productive and I learnt a lot.
The experiences I had made were one reason why I was offered a job as a Research Analyst at Delft Technical University. I develop enzyme tests using fluorescence techniques in the sub- nanoliter-range. I also measure enzyme kinetics with special a microscopic device.
I am currently working for my PhD thesis and just now preparing two presentations for an international congress in California.
I want to add that the two placement periods in the Netherlands stimulated my interest in a foreign country – and gave me a chance to learn another foreign language, Dutch."

KEY ELEMENTS OF THE BOLOGNA PROCESS: PERMEABILITY, MOBILITY, EMPLOYABILITY

During the implementation of the Bologna process in European countries, a series of meetings of the stakeholders has taken place. They have produced a series of communiqués. The last one was published in Leuven/Louvain, Belgium, April 29th, 2009.
What in the present contribution is called permeability has become more and more important during the development of the Bologna process:
"10…..Lifelong learning implies that qualifications may be obtained through flexible learning paths, including part-time studies, as well as workbased routes. 11….. Successful policies for lifelong learning will include basic principles and procedures for recognition of prior learning on the basis of learning outcomes regardless of whether the knowledge, skills and competences were acquired through formal, non-formal, or informal learning paths. Lifelong learning will be supported by adequate organisational structures and funding. Lifelong learning encouraged by national policies should inform the practice of higher education institutions.
12.….The development of national qualifications frameworks is an important step towards the implementation of lifelong learning. We aim at having them implemented and prepared for self-certification against the overarching Qualifications Framework for the European Higher Education Area by 2012. This will require continued coordination at the level of the EHEA and with the European Qualifications Framework for Lifelong Learning. Within national contexts, intermediate qualifications within the first cycle can be a means of widening access to higher education." [17]

Horizontal, i.e. transnational mobility is even called a hallmark of the European Higher Education Area:
"18. … Mobility is important for personal development and employability, it fosters respect for diversity and a capacity to deal with other cultures. It encourages linguistic pluralism, thus underpinning the multilingual tradition of the European Higher Education Area and it increases cooperation and competition between higher education institutions. Therefore, mobility shall be the hallmark of the European Higher Education Area. We call upon each country to increase mobility, to ensure its high quality and to diversify its types and scope. In 2020, at least 20% of those graduating in the European Higher Education Area should have had a study or training period abroad.
19. Within each of the three cycles, opportunities for mobility shall be created in the structure of degree programmes. Joint degrees and programmes as well as mobility windows shall become more common practice. Moreover, mobility policies shall be based on a range of practical measures pertaining to the funding of mobility, recognition, available infrastructure, visa and work permit regulations. Flexible study paths and active information policies, full recognition of study achievements, study support and the full portability of grants and loans are necessary requirements." [17]

Finally, the importance of employability aspects is stressed in the Leuven/Louvain document, and integrated placements are recommended: "13. With labour markets increasingly relying on higher skill levels and transversal competences, higher education should equip students with the advanced knowledge, skills and competences they need throughout their professional lives. Employability empowers the individual to fully seize the opportunities in changing labour markets. We aim at raising initial qualifications as well as maintaining and renewing a skilled workforce through close cooperation between governments, higher education institutions, social partners and students. This will allow institutions to be more responsive to employers needs and employers to better understand the educational perspective. Higher education institutions, together with governments, government agencies and employers, shall improve the provision, accessibility and quality of their careers and employment related guidance services to students and alumni. We encourage work placements embedded in study programmes as well as on-the-job learning." [17]

SUMMARY

This brief review reports on elements of a flexible, transparent and proven toolbox in chemistry education which allows for individual development of students at the VET and the HE levels. It demonstrates the feasibility of permeability (mobility across educational level barriers) and transnational mobility in the sector and may serve as a model for other sectors. The

"toolbox" described here exactly meets the requirements of the most recent document of the Bologna process.

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The support of professional bodies like ECTN, EMCEF/ECEG, the Chemical Societies of Germany, Czech Republic and the UK is gratefully acknowledged.

IGIP's general assembly under its then president Federico Flueckiger made an important contribution during the 33rd Symposium in Fribourg/CH, when the importance of industrial placements was not yet duly taken into account in the Bologna process [18].

One of the most important cornerstones of the "House of Chemical Education" is the constant support by the EU commission in a series of mobility, pilot and network projects (listed in [2]), of the German Academic Exchange Council DAAD and the Bundesinstitut für Berufsbildung BIBB with their dedicated, service oriented staff. Finally, the author would like to thank Dipl.-Ing. Maren Horz for her constant, reliable and creative work in our EU projects.

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This site also contains the Budapest descriptors for Chemistry.

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[18] Position paper of IGIP, which says, among others: "Employability of Bachelor graduates as one of the leading principles of the two tier system of education shall be duly taken into account. Therefore IGIP encourages academic institutions to offer practical experience as an essential part of the engineering curriculum. This is in particular true for application oriented study programmes. Consequently, the official study time for such programmes must not be limited to 6 theoretical semesters (180 credits). IGIP strongly recommends that academic institutions be allowed to offer 7 (210 credits) or 8 (240 credit) courses, in accordance with the Bologna "corridor" for Bachelor courses."