# Best practices in syllabus design and course planning applied to mechanical engineering subjects

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## Abstract

The syllabus of a subject, that is part of the curriculum of a bachelor's or master's degree, must provide the student with information about all the fundamental aspects of the subject. It is a piece of written document or multimedia file encompassing all topics and concepts that will be covered in a certain subject. The objective of the syllabus is to put the subject and the information related to it in context by means of clear, organized, concise and summarized style. It should not be limited only to the subject matter. Instead, it is advisable to provide basic course information such as the number of credits; course content; transversal competences, skills and attitudes that are relevant for access to work and further learning; faculty staff; assessment and evaluation elements; calendar; venues, and facilities location; lesson plans and bibliography. Moreover, information about the activities to be carried out and whether they are done individually or in groups. Another important point is the evaluation of students and how to assess their achievements in terms of the level of acquisition of knowledge and skills planned in the subject. It helps students to meet the desired subject objectives and to motivate them. In short, it will lay the foundations so that at least contents, methods and techniques of the discipline that supports the subject can be taught and so that students can acquire the knowledge and competences committed.

**Keywords:** Syllabus, transversal competences, effective teaching-learning process, effective teaching, learning targets, student evaluation elements, alumni motivation

## 1. Introduction

The beginning of a new term is a critical period in the student's learning process. Students enrolled in a bachelor's or master's degree must face a situation of uncertainty related fundamentally to the content, the development of each subject, the teaching methods, and the way they are assessed and evaluated (Nunan, 1988).

There is also some degree of uncertainty regarding the knowledge that students have about the teaching staff, the resources that will be deployed, the places where the teaching will take place (classrooms, laboratories, etc.) and the most important dates related to them (dates of laboratory work, exam dates, handing assignments dates, etc.). This situation of uncertainty is usually addressed in the first-class session. The subject syllabus is intended not only to reduce the student's uncertainty and anxiety, but also to act actively to enhance and encourage the acquisition of knowledge and skills of students in relation to the subject to be presented (Millis, 2009; Jones et al., 2015).

The subject syllabus is very important since it is the first interaction between the student and the subject. It is equivalent to having a first impression of the subject. It fulfils at least two basic objectives: on the one hand, it serves to make known the most important aspects of the subject (contents and assessments acts), putting it in context and orienting the student; and on the other hand, it serves as a reference to recall and retrieve information related to the subject that the teacher has made available to the student at any time between the beginning and the end of the course (Robb, 2012).

The content of the subject syllabus should not be limited to reflecting the teaching guide but to contain complementary and necessary information for a correct understanding of the subject in the context of the degree or master's degree in which it is taught. Furthermore, it should boost the alumni motivation and need to take the subject.

When a student begins a term must deal with different subjects from which they have very little information. Students face a situation in which they do not know the contents that await them throughout the four-month period, nor the workload that they will have to carry out in order to pass the different subjects. They usually wait until the first day of class of each subject to obtain the information they need and to check to what extent their expectations will be fulfilled in terms of

content and to gauge whether they have the necessary resources and skills to acquire an adequate level of knowledge and competencies.

The name of the subject is usually indicative of what its content will be, but obviously the name is not enough to know the scope and importance of the subject, what the specific contents will be, the faculty in charge of teaching, etc.

Much of the information related to a given subject is made available to students on the online technological platforms. In the case of Universitat Politècnica de València (UPV) in Spain, the tool that host all this information and supports teaching is called Poliformat. It is based on Sakai, which is a free, community source, educational software platform designed to support teaching, research, and collaboration. Sakai is developed by a community of academic institutions, commercial organizations, and individuals. It is distributed under the Educational Community License (a type of open-source license).

However, very few people take the time and trouble to consult this tool in order to access the available information. This circumstance may have a very simple explanation: the student expects the professor to shed light on the subject in question, at least on the first day of class.

It is in this context that the subject syllabus takes on its full meaning. It will dispel all the questions that the student may have about the subject, and that will help to improve the students' performance, since they will not have the worries, uneasiness and anxiety linked to the uncertainty of what may be unknown (Slattery and Carlson, 2005).

In addition, with the reasonable teaching differences inherent of each subject, they usually present many disparities in terms of content, learning methods used, evaluation elements for the assessment, evaluation dates, weights of each part in obtaining the final grade for the subject, etc. It is difficult for the student to retain in memory all the details of all the subjects that make up the four-month period (Tiana et al., 2011). In this sense, the subject syllabus fulfils its second major task, to be a reference document or multimedia file throughout the term for the student in relation to the content and continent of each subject. In this sense, they can consult through the online platform anywhere at any time all kinds of information related to each subject, particularly information on

dates, group formation, methods of delivery of laboratory works, percentages that each element of evaluation has on the final grade of the subject, evaluation system, etc.

It should also be noted that many subject syllabi are too brief and simplified. On the contrary, there are others that are very dense, with too much information and even with contents that are not appropriate for a subject syllabus (Tokatli and Kesli, 2009).

Whether it meets the established objectives or not will depend on the degree of elaboration of the presentation topic and whether the contents are presented in a clear and organized way.

## 2. Best practices in syllabus design and course planning.

The subject syllabus can be approached from different perspectives. For example, one could distinguish between first-year subjects from the rest. For the first year, everything is unknown to the student, including the university and its facilities, so the type of information required is different. Regardless of the perspective with which the subject syllabus is prepared, it could be said that it will be good when the student finds it unnecessary to search for any information related to the subject by using sources other than those provided for in the subject itself. At that point it could be concluded that an excellent subject syllabus has been prepared in relation to the relevant subject.

Therefore, from the perspective of a student who is already in college or university, this topic should contain at least the following sections:

a) Baseline course information and teaching staff.

b) Fit and function of the subject in the degree program.

c) Calendar, venues, and facilities location.

d) Competencies.

e) Didactic units and teaching methods.

f) Evaluation systems and assessment acts.

g) Tutorships.

h) Student-teacher communication.

i) Bibliography.

Each of these sections is explained in detail below:

a)    <u>Baseline course information and teaching staff</u>: it should include course name and number, term and year, credit hours, location and timetable of class meetings, and teaching staff. A virtual teaching contingency plan for online or blended/hybrid teaching in an exceptional situation caused by exceptional problem such as COVID-19 should also be provided. In general, the quality and training of the university academic body and particularly of the faculty is fundamental for the academic, social, and cultural development of the students. Descending to the level at which the subjects are taught, the importance of the professor is undeniable. On most occasions, he or she becomes the soul that gives a subject a life of its own. The role of the teacher is not limited to transferring the competencies, the contents of the subjects and to enabling and directing the evaluation process of that subject. They become a mirror in which students look at themselves. They constitute the main reference that students have in their formative process. These tend to emulate or repudiate their scale of values, their vision of reality, etc.

There are many aspects to highlight about the teaching staff:

- Relevance in the ethical and moral formation of students.
- Well-being of the teaching staff in its triple aspect: manager, teacher, and researcher.
- Level of academic and skills training

University teachers face many problems derived from a demanding work context produced by educational reforms related to the working of the university. They must remain attentive to the pedagogical level they deploy, enabling mechanisms to develop the democratization of educational scope, encouraging participation, and pluralism.

They must undergo a continuous process of updating on issues such as new learning methodologies, content development and subject planning, as well as evaluation processes. In short, teachers must be trained and committed to the performance of their work and have a positive attitude to accept and understand the differences of the students they will be in charge of.

In addition, they are also subject to student criticism and a survey-based assessment process. It is vital to introduce teacher training programs to professionalize the work, promote new competencies related to inclusion and attention to diversity in university teaching institutions.

In all, the subject syllabus must contain at least the name of the coordinator or person in charge of the subject, although usually the entire teaching staff is included.

b)      The fit and function of the subject in the degree: it is essential to justify the existence of the subject in the degree, the relationship it has with the other in the course, as well as the applications and professional opportunities to which the acquired knowledge may lead. The subject goals, objectives and learning outcomes must be provided.

It serves to give meaning to the subject, offering a context in which it is developed. The degree (or in its case the master's degree) must have a coherent corpus of studies that is made explicit through its syllabus. This is usually drawn up by specialists and experts and it must reflect the areas of knowledge that must be part of it in order to meet the training objectives. The different subjects come to fulfil the areas of knowledge and make up the curriculum of a given degree. This is the origin of the relationship between certain subjects in the curriculum.

In order to adequately cover the areas of knowledge, the descriptors of the subject areas and sub-areas are used. They are indicative of the contents sought. The suitability of the subject within the syllabus of which it forms part is justified by these descriptors. The student must participate in the thematic areas of the degree and focus the subject as an important part to cover this thematic area. Defining the thematic area of the subject and the set of competences that will be worked on will serve as motivation for the students to follow the subject.

The subject syllabus should include a brief description of the subject and the minimum recommended knowledge, in order to review the knowledge acquired in other subjects.

c)      Calendar and venues and facilities location: teaching sessions calendar, assignment due dates and assessment dates must be provided. Also, how holiday periods and professional or university events affect class meetings. In addition, especially in universities, which sometimes have huge campuses with facilities distributed in different locations within the campus, it is very important to clarify the rooms, classrooms, laboratories, and other venues in which the teaching of the subject will take place. Even more during the first days of the term, when students are lost and are not able to find the venues and facilities where a certain activity is going to take place, such as a master class, a laboratory work session, or a field activity.

It is necessary to have good information about sites and places. The use of maps, the assignment of names to buildings, streets, classrooms, laboratories, etc. will help the students in the search for these facilities.

It is a help that should be included in the subject syllabus, especially when there is a very heterogeneous student body that is not used to these places. This is often the case with Erasmus-type students, with those who apply for a transfer to another university, etc.

In a nutshell, this information makes life easier for all members of the university community.

d)      Competencies: they are defined as the set of abilities, skills, knowledge, attitudes, and abilities that are acquired during participation in the teaching of a subject.

On the other hand, the enumeration of the competencies that are expected to be developed in a subject are necessary in the degree accreditation processes.

Therefore, it is necessary not only to define them but also to implement the processes for their evaluation and to see to what degree these competencies have been achieved by the students.

It is necessary to distinguish (according to UPV, 2020) between:

- Specific competencies: those that are carried out in the development of the subject itself. Each subject must indicate which are the basic competences, capacities and personal skills that must be acquired throughout the development of the subject.
- Transversal competences: these are skills related to personal development, which do not depend on a specific thematic or disciplinary field but appear in all domains of professional and academic performance. It is a very complex know-how, so it is necessary to specify it in more specific learning outcomes.

Within the scope of the subject syllabus, it is convenient to explain to the students which the competences (specific and transversal) are related to the subject. It is also necessary to make explicit the way in which they are assessed by defining several degrees of achievement that will help students to determine the level of skill acquired in such competences at the end of the teaching of the subject.

e)      Didactic units and teaching methods: a didactic unit is a piece of information that provides the backbone of the contents of the subject. They imply a method to organize and plan the teaching and learning process.

The didactic units must contain at least the following information:

- Name of the didactic unit or topic.

- Quantity: indicate how many didactic units or topics exist in the syllabus.

- Content: a brief index of each didactic unit. The set of contents of the didactic units makes up the teaching and academic corpus of the subject. It must include traditional materials and e-resources that students have at their disposal, such as: coursebooks and other learner materials; available information and communications technologies, such as educational platforms, recorded lectures, multimedia, online and computer-based materials; activities, tasks and exercises designed for use in and out of the classroom; and recommended bibliography.

Teaching-learning method is "a coherent set of logically coordinated techniques and actions to direct student learning towards certain learning outcomes" (UPV, 2020).

For an effective teaching development, the following headings should be designed:

- Theory sessions: these are sessions where the master class is developed.
- Seminar: group work technique, which is clearly different from the master class, students become familiar with the means of research and reflection.
- Classroom work
- Laboratory work
- Computer work
- Evaluation activities

f)      Evaluation systems and assessment acts: the evaluation systems and assessment acts of each subject represent a very important point, which together with the faculty responsible for it must be specified in the teaching guide of the subject before the beginning of the subject. According to university regulations, the evaluation system cannot be modified during the course. A distinction must be made between assessment acts and evaluation systems. The evaluation system of each subject is an instrument for monitoring and assessing the results obtained by the students in the teaching-learning process. The evaluation system will include the means of evaluation used, the number of assessment acts, the weight of these in the final grade and the recovery procedure.

The faculty in charge of teaching a subject will evaluate the students enrolled in that subject in accordance with the provisions of the regulations in force (considering the objectives of each degree and the resources available).

An act of evaluation is understood as that activity that allows the orderly collection of information on the student's teaching-learning process, through one or more means of evaluation, in order to determine the degree of assimilation of the learning results foreseen in the subject.

The means of evaluation that can be established in the teaching guide are the following:

- Open answer written test: timed test carried out under the control of the teacher, where the student must respond in their own words and in writing, to one or more questions related to the didactic units of the subject. Occasionally, they may consult the notes, documentation, support material and/or access the Internet.

- Objective test: written exam structured with several questions or items, in which the student either chooses the answer he/she considers correct or complements it with precise elements such as a word or short phrase.

- Oral exam: technique related to oral expression and the student's active participation in learning in relation to: mastery of contents, communicative skills, attitudes, reflective processes, etc. They can often be a complement to written tests, academic papers, etc.

- Academic work: evaluation technique that includes the work done by the students, from short and simple work to extensive and complex work typical of the last courses: TFG, TFM, doctoral thesis...

- Project: means of evaluation that allows the assessment of both the projects developed by students, as well as the skills, competencies and knowledge acquired with their development.

- Problems: Means to evaluate the knowledge and skills used by the student when facing and solving a problem designed by the teacher. Teaching-learning method whose starting point is a problem designed by the teacher, so that the student, not having all the information, must reflect and identify their needs. To solve it correctly, the student must search, understand, and integrate the basic concepts of the subject.

- Cases: evaluation technique especially indicated to evaluate the different cases solved by the students.

- Portfolio: a structured set of documents, prepared by the student, which gathers evidence that demonstrates their knowledge and competencies (learning level) in a subject or course, in relation to the criteria-guidelines stipulated by the teacher.

- Journal: it is a personal report, a narrative about an assignment, in which students detail the actions undertaken in their learning, including their concerns, feelings, observations, questions, hypotheses, explanations, etc.

- Observation: strategy based on the systematic collection of data in the learning context itself, on students' performance, skills, abilities, and attitudes. It can be carried out through different instruments such as anecdotal records, checklists, and rating scales.

- Minute tests: these are open questions -one or two- that are asked minutes before the end of a class and they allow evaluating what the students have understood from what they have seen in class, in a specific reading, article, activity, etc.

It is possible for the students themselves to generate closed-answer questions. UPV may include any other method it deems appropriate. It should also include the attendance policy and expected classroom behaviour (e.g., cell phone and laptops use).

g)      Tutorship: information on tutorship is an element to be taken into account in the subject syllabus. Tutorship is an act that the teacher carries out on the students, and it consists of a particular help to the student to facilitate the teaching-learning process and therefore helps their academic progress. It can have a face-to-face or virtual format using an educational platform. Therefore, contact information, and teacher's office location and mentoring hours must be provided.

h)      Student-teacher communication: these are the channels through which the student and the teacher interact. Apart from the direct contact that may exist during the development of a teaching session in its different formats, it is necessary to establish additional and complementary channels of communication.

One of these methods can be through e-mail, announcements in the technological platform of communication with the student (Poliformat), etc.

i)      Bibliography: it is the list of books or other types of writings (articles, book chapters, etc.) and information sources that are used as support or consultation material for the understanding, development and research related to the content of the subject.

A bibliographic reference must contain at least the following elements: author's name, full title, and year of publication.

In general, the bibliographic reference should be concrete and concise, including only the necessary information; at the same time, it should be formal, exhaustive, and reliable, i.e., it should not omit or obviate important data.

## 3. Improving and updating the subject syllabus

When teachers prepare the subject syllabus and includes all the information referred to in the previous sections, they may have the feeling that the topic is finished, that it is complete and that there is no room for further improvements and contributions. However, it lacks the most important test, which is the acceptance and recognition as such by the students.

That is why it is important to have a continuous improvement process that takes into account the suggestions done by the students (of the different courses or promotions that will receive it).

There is always some nuance to be added or some clarification to be made. For this reason, the subject syllabus improves with the external contributions made mainly by the students. In some cases, things as simple as introducing icons, using a graphic or an image, or even some animation or video substantially improve the content and understanding of the subject syllabus.

In any case, it is important do not disregard any suggestions received from external sources and study them in case they could be useful in improving the subject syllabus.

It is also necessary to update the subject syllabus because there may be sections that change from one term to another. For example, the headings related to the schedule of classes and laboratory work sessions. Also, the proposed dates of evaluation events, etc. Therefore, in addition to a continuous process of improvement, a continuous updating of the subject is necessary.

## 4. Discussion and conclusions

The outcome of the subject syllabus can be measured by the students' satisfaction with the information provided by it. It is open here to all teachers and researchers to make their contributions to improve the content of the subject syllabus. Thus, it is necessary for teachers to be involved in this issue.

It is worth mentioning the extensive experience of the authors of the present paper with many subjects in the field of Mechanical Engineering. Note that to effectively transmit knowledge to students it is important that teachers keep up to date with educational and technological advances concerning these subjects. In this sense, they have published many articles in recent years closely related with the aforementioned subjects. For instance, Llopis-Albert et al. (2015-2022); Rubio et al., (2015-2021); Valero et al. (2017, 2019); Valera et al. (2021); Zeng et al. (2022).

The authors have successfully applied the present methodology and implement the best practices in syllabus design and course planning in the mechanical engineering subjects that they teach. The success of the developed methodology is demonstrated by the fact of the highly alumni satisfaction as shown by the mandatory surveys that the university implement in all the subjects as a measure of the teaching quality. Furthermore, student satisfaction has increased over the years as the syllabus has been improved, while the best practices discussed above have been applied and suggestions from students and other faculty have been implemented.

These surveys are in line with the current system of the Spanish university system, that guarantees the training and competence of the teaching staff. This system rests with universities and, consequently, they must develop procedures for the assessment of their performance, as well as for their training and encouragement, guaranteeing their qualification and teaching competence. To favour this evaluation of teaching, the National Agency for Quality Assessment and Accreditation (ANECA) launched in 2007, in close coordination with the regional evaluation agencies, the Support Program for the Evaluation of the Teaching Activity of University Professors (DOCENTIA) with the aim of supporting universities in the design of its own mechanisms to manage the quality of the teaching activity of university teaching staff and favour its development and recognition. The DOCENTIA Program takes as a reference the recommendations for quality assurance in higher education institutions, contained in the document Criteria and Guidelines for Quality Assurance in

the European Higher Education Area (2015), which was approved by the Conference of Ministers signatories of the Bologna Declaration in May 2015. Likewise, in the design of the program, the standards established by internationally recognized organizations in the field of personnel evaluation have been taken into account, such as The Personnel Evaluation Standards, prepared by The EU Joint Committee of Standards for Educational Evaluation. At this moment, more than 90% of the universities participate in this program, throughout its different phases.

In conclusion, reaching a lively classroom atmosphere and fruitful learning process can be enhanced by designing an efficient syllabus and course planning, for which an active involvement of the teaching staff and students is desirable. This leads to a higher degree of student satisfaction, their motivation to approach the subject and achieve the learning objectives is enhanced, and therefore, to an improvement in their academic performance is attained.

## References

Jones, S.K., Noyd, R.K., Sagendorf, K.S. (2015). Building a Pathway to Student Learning: A How-To Guide to Course Design. Stylus Publishing, LLC.

Llopis-Albert, C., Rubio, F., Valero, F. (2015). Improving productivity using a multi-objective optimization of robotic trajectory planning. Journal of Business Research, 68 (7), 1429-1431. https://doi.org/10.1016/j.jbusres.2015.01.027

Llopis-Albert, C., Rubio, F., Valero, F. (2018). Optimization approaches for robot trajectory planning. Multidisciplinary Journal for Education, Social and Technological Sciences, 5(1), 1-16. https://doi.org/10.4995/muse.2018.9867

Llopis-Albert, C., Rubio, F., Valero, F. (2019). Fuzzy-set qualitative comparative analysis applied to the design of a network flow of automated guided vehicles for improving business productivity. Journal of Business Research, 101, 737-742. https://doi.org/10.1016/j.jbusres.2018.12.076

Llopis-Albert, C., Rubio, F. (2021). Methodology to evaluate transversal competences in the master's degree in industrial engineering based on a system of rubrics and indicators. *Multidisciplinary Journal for Education, Social and Technological Sciences* 8(1), 30-44. https://doi.org/10.4995/muse.2021.15244

Llopis-Albert, C., Palacios-Marqués, D., Simón-Moya, V. (2021). Fuzzy set qualitative comparative analysis (fsQCA) applied to the adaptation of the automobile industry to meet the emission standards of climate change policies via the deployment of electric vehicles (EVs). *Technological Forecasting and Social Change*, 169, 120843. https://doi.org/10.1016/j.techfore.2021.120843

Llopis-Albert, C., Rubio, F., Zeng, S., Grima-Olmedo, J., Grima-Olmedo, C. (2022). The Sustainable Development Goals (SDGs) applied to Mechanical Engineering. *Multidisciplinary Journal for Education, Social and Technological Sciences* 9(1), 59-70. https://doi.org/10.4995/muse.2022.17269

Millis, B.J. (2009). The Syllabus Toolbox: A Handbook for Constructing a Learning- Centered Syllabus, University of Texas, San Antonio.

Nunan, D. (1988). Syllabus design. *Oxford: Oxford University Press*. ISBN: 0194371395, 177 pages.

Robb, M.S. (2012). The Learner-Centered Syllabus. *The Journal of Continuing Education in Nursing,* 43(11), 489-490. https://doi.org/10.3928/00220124-20121024-26

Rubio, F., Llopis-Albert, C., Valero, F., Suñer, J.L. (2015). Assembly Line Productivity Assessment by Comparing Optimization-Simulation Algorithms of Trajectory Planning for Industrial Robots. *Mathematical Problems in Engineering*, Volume 2015, Article ID 931048. https://doi.org/10.1155/2015/931048

Rubio, F., Llopis-Albert, C. (2019). Viability of using wind turbines for electricity generation in electric vehicles. Multidisciplinary Journal for Education, Social and Technological Sciences, 6(1), 115-126. https://doi.org/10.4995/muse.2019.11743

Rubio, F., Llopis-Albert, C., Valero, F. (2021). Multi-objective optimization of costs and energy efficiency associated with autonomous industrial processes for sustainable growth. *Technological Forecasting and Social Change*, 173, 121115. https://doi.org/10.1016/j.techfore.2021.121115

Slattery, J.M., Carlson, J.F. (2005). Preparing An Effective Syllabus: Current Best Practices. *College Teaching* 53(4), 159-164. https://doi.org/10.3200/CTCH.53.4.159-164

Tiana, A., Moya, J., Luengo, F. (2011). Implementing key competences in basic education: reflections on curriculum design and development in Spain. *European Journal of Education* 46(3), 307-322. https://doi.org/10.1111/j.1465-3435.2011.01482.x

Tokatli, A.M., Kesli, Y. (2009). Syllabus:how much does it contribute to the effective communication with the students? *Procedia Social and Behavioral Sciences* 1, 1491–1494. https://doi.org/10.1016/j.sbspro.2009.01.263

UPV (2020). Proyecto institucional competencias transversales. Universitat Politècnica de València (UPV). Valencia. Spain. https://www.upv.es/entidades/ICE/info/Proyecto_Institucional_CT.pdf

Valera, Á., Valero F., Vallés M., Besa A., Mata V., Llopis-Albert C. (2021). Navigation of autonomous light vehicles using an optimal trajectory planning algorithm. *Sustainability*, 2021; 13(3):1233. https://doi.org/10.3390/su13031233

Valero, F., Rubio, F., Llopis-Albert, C., Cuadrado, J.I. (2017). Influence of the Friction Coefficient on the

Trajectory Performance for a Car-Like Robot. *Mathematical Problems in Engineering*, 9 pages. Article ID 4562647. https://doi.org/10.1155/2017/4562647

Valero, F., Rubio, F., Besa, A.J., Llopis-Albert, C. (2019). Efficient trajectory of a car-like mobile robot. *Industrial Robot: the international journal of robotics research and application*, 46(2), 211–222. https://doi.org/10.1108/IR-10-2018-0214

Valero, F., Rubio, F., Llopis-Albert, C. (2019). Assessment of the Effect of Energy Consumption on Trajectory Improvement for a Car-like Robot. *Robotica,* 37(11), 1998-2009. https://doi.org/10.1017/S0263574719000407

Zeng, S., Zhang, Na, Zhang, C., Su, W., Llopis-Albert, C. (2022) .Social network multiple-criteria decision-making approach for evaluating unmanned ground delivery vehicles under the Pythagorean fuzzy environment. *Technological Forecasting and Social Change*, 175, 121414. https://doi.org/10.1016/j.techfore.2021.121414