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Report on the skills to suggest to ESCO

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Report on the skils to suggest to ESCO

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1. Executive Summary

The following report presents the description of task T2.3 “Skills2ESCO”, as well as the methodological steps and the results obtained.

The aim of this task is to find Green, Digital and Entrepreneurial (GDE) skills that can be incorporated into the ESCO database. In particular, the results coming from T2.1 “Categorising ESCO skills on GDE skills” will possibly generate new GDE skills which did not exist before as skills, or as alternative labels of skills. These skills will be validated in T2.2 “Enhancement and revision of the identified skills by the companies” and formalized in T2.3 “Skills2ESCO” according to the ESCO standard to make them suitable to be included within the ESCO database. Indeed, being part of such classification would be of great importance for both Education and Training providers and companies within the project. In the report, we define competence as both skills and knowledge of the ESCO database. Moreover, we use the term “skill” as a synonym of the word “competence”, referring to both skills and knowledge of ESCO, to ease the reading process. Many authors relied on the ESCO database to analyse the skills need for a domain. For instance, Spada et al. (2022a) analysed the mismatch between skills of companies' needs and skills provision by universities, using the ESCO database. Fareri et al. (2021) developed a natural language processing system able to extract soft skills using ESCO.

The *input* of this task is the list of extracted skills from task T2.1 “Categorising ESCO skills on GDE skills” and the ESCO database. The *process* consists of four steps aiming at finding correspondences between extracted skills and ESCO competencies, through different approaches. In each step the initial input list is progressively reduced. The adopted approaches are described briefly. Then a detailed description is provided in Section 2 “Skill2ESCO Methodological Steps”. The Skill2ESCO is composed of the following steps:

1. **Exact Matching** - automatic search for an exact match with the preferred/alternative label of ESCO. In particular, the table containing the skills extracted from scientific papers and the table containing preferred and alternative labels of the ESCO competencies were compared to join the exact correspondences.
2. **Similarity Matching** - automatic computation of the semantic similarity between each skill identified in scientific papers and the preferred label of each ESCO skill.
3. **Manual Revision** - manual revision of the most similar skills resulted from the semantic similarity algorithm.
4. **Definition Comparison** - expert evaluation to determine if the skill extracted in scientific papers falls under the definition of any skill presented in the ESCO database.

The *output* of this task is the list of actions for the GDE skills extracted from the scientific literature that can be incorporated within the ESCO database. The full list of actions is reported in Section 3 “Results”.

ESCO is the European multilingual classification of Skills, Competences and Occupations (https://esco.ec.europa.eu/en). ESCO works as a dictionary, describing, identifying, and classifying professional occupations and skills relevant to the EU labor market and education and training. Those concepts and the relationships between them can be understood by electronic systems, which allow different online platforms to use ESCO for services like matching job seekers to jobs based on their skills, suggesting training to people who want to reskill, or upskill, etc.

It is continuously updated to be aligned with the labor market[1]. As of July 2022, ESCO provides descriptions of 3,008 occupations and 13,890 skills linked to these occupations, translated into 28 languages. The aim of ESCO is to support job mobility across Europe and therefore a more integrated and efficient labor market, by offering a "common language" on occupations and skills that can be used by different stakeholders on employment, education, and training topics. ESCO is based on the International Standard Classification of Occupations (ISCO-08), which structures the set of concepts (skills and profiles) in a hierarchy to facilitate the navigation of the taxonomy.

The ESCO skills pillar uses a broad definition of skills that encompasses not only skills, but also knowledge, skills, and competencies. For each concept, the following information is provided: one preferred label, some alternative expressions to address the given concept, a description, a tag for the type (e.g., skill or knowledge), and the list of professional profiles which need the given skill/knowledge.

2. Skill2ESCO Methodological Steps

Task T2.3 "Skill2ESCO" consists of a projection of the skills from the three lists of each domain on the ESCO database. In Figure 1, the main methodological steps of the T2.3 Skill2ESCO task are shown. The extraction of the GDE skills made in task T2.1 resulted in 1,107 unique skills, which are distributed in the three analysed domains, in particular 461 Green skills, 728 Digital Skills and 718 Entrepreneurial skills[2].

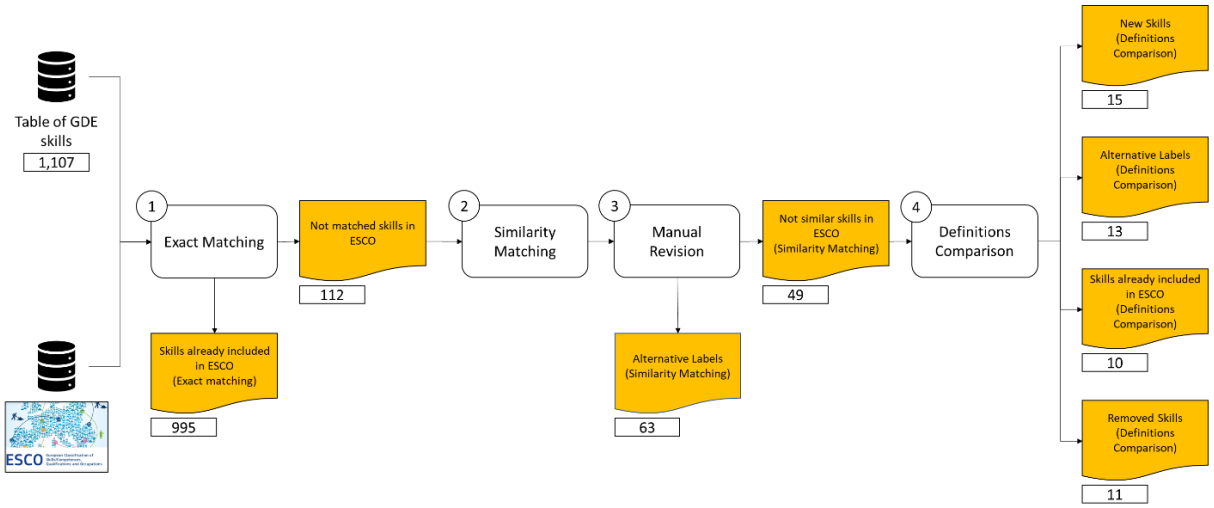

Figure 1. Workflow diagram to describe the steps of Task 2.3 Skill2ESCO.

Starting from this list, the first step, named **Exact Matching** (in Figure 1), is fully automatic as the skills are compared with an exact match technique. The list of skills detected in task T2.1 includes information for the presence/absence of each skill in the ESCO Database. Using this information, the skills contained in ESCO have been automatically linked to the skills. The number of skills that found an exact match with ESCO is 995 out of 1,107.

The second step, named **Similarity Matching** (in Figure 1), can be considered a mixture of automatic and manual approaches. The skills that have not been matched with ESCO in the previous task are 112.

[1] Last update in January 2022 - https://esco.ec.europa.eu/en/news/esco-v11-live.

[2] Summing the number of skills of each domain, the result is different from the number of total skills (1,107) because we must consider the number of skills in common between the three domains.

Each of these skills is automatically compared with the list of ESCO skills using text mining for identifying the most similar skill. For each non-matched skill, the top 4 most similar ESCO skills are identified. In Table 1, we report an example of the results, where we can observe: in the first column the list of non-matched skills, in the second column the top 4 most similar ESCO skills, and in the third column the semantic similarity between each pair of strings. The Bidirectional Encoder Representations from Transformers (BERT) model (Devlin et al., 2018) is used to map each extracted entity and ESCO competence into a vector and multidimensional semantic space. BERT is used by different works in literature to identify similarities between skills-related concepts, such as technologies (Giordano et al., 2021; Spada et al., 2022b; Puccetti et al., 2023). Converting skills into vectors is effective for identifying similarities between them, as recently demonstrated by Chiarello et al. (2021). The cosine similarity between all the extracted vectors and all the ESCO skills' vectors is calculated as the cosine of the angle between the two semantic vectors (Han et al., 2011) to determine the semantic similarity.

Table 1. Examples of non-matched concepts and top 4 most similar ESCO skills.

Non-matched concept	Top 4 most similar ESCO skills	Semantic Similarity
Zoom	mount optical components on frames	0,54
	take pictures	0,54
	cameras	0,53
	Havok Vision	0,52
Youtube	social media management	0,49
	Internet of Things	0,48
	select video shots	0,47
	apply social media marketing	0,46
working with others	instruct others	0,76
	communicate professionally with colleagues in other fields	0,75
	cooperate with colleagues	0,73
	motivate others	0,73
working conditions	work in shifts	0,78
	deal with challenging work conditions	0,75
	visit places of work	0,73
	supervise the work of staff on different shifts	0,73

work together	work in teams	0,80
	develop working procedures	0,75
	carry out work-related measurements	0,75
	work efficiently	0,74

As we can observe in Figure 1, in the third step we manually review each non-matched concept reported in Table 1 to choose the most meaningful pairs, to have one pair per skill. However, some skills within all three domains are not associated with any skills in the ESCO database as the writing style of scientific literature is not always in line with the standard language of ESCO. On the other hand, some items extracted in the scientific papers cannot be associated with the ESCO skills as they are not related to the domains under analysis; typically, in these cases, the expressions in scientific literature refer to concepts different from skills.

Summing up, the number of skills that we match within this second step, using semantic similarity, is 63 out of 112. These 63 concepts can be proposed as alternative labels of the corresponding ESCO skills to whom they were matched. Therefore, they have been checked and modified where necessary in order to ensure the alignment with ESCO language.

The remaining 49 skills pass through the fourth step, named **Definitions Comparison**. This step is different from the first two, as it is fully based on expert judgment. Therefore, the list of unmatched skills has been checked manually by domain experts. To execute the task "Definitions Comparison", the experts must have experience with the ESCO database and know how the Natural Language Processing algorithm works. The pool of experts consists of one student with a Master's Degree in Data Science and Business Informatics, three Ph.D. students, and one researcher; all of them have experience in skills analysis (in ESCO, but also in other international databases, such as O*NET) and strong Natural Language Processing (NLP) expertise. The purpose of this task is to find possible relations among the items detected in scientific literature and the ESCO concepts considering their definitions. Each item has been defined with the purpose to have a shared vision about the definition of a given skill. Then, it has been reported on the ESCO portal search bar and the matches for some entries have been identified by reading the first several results of the skills/knowledge. The description of each skill has been analysed to verify the connection with the above-mentioned definition of a given skill. Therefore, the related descriptions have been associated with the skills. When the results of the ESCO search do not provide any relevant concept for the given item, the experts can discuss proposing the concept as a new one for the ESCO repository. The revised skills have been assigned with the following labels of action:

1. **Added as an alternative label** - in the case when one ESCO skill description matches with the skill's actual description. The actual label has been provided.
2. **Proposed as New Skill** - in the case when none of ESCO skills matches with the skill's actual description. The description and actual label have been provided.
3. **Cannot be included** - in the case when the skill cannot be considered as an ESCO skill. The explanation of why the skill cannot be included has been provided for each of the items analysed.

Experts were allowed to use external sources for achieving their goals. The results are then compared and if there was disagreement, the experts, led to the researcher, start a debate and converge on a common solution. The task required more or less 2 hours for each expert.

In total 12 expressions have been labeled as "Cannot be included". Even though those are addressed as skills in scientific literature, they cannot be intended as skills within the scope of ESCO. The reasons may vary, indeed for each of their different types of explanations have been provided, such as:

- **Referring to a general concept** - in case the entity is too generic to be considered as a skill e.g., *education*, *working conditions*, *independence,* and such.
- **Referring to a general state of a person** - in case the entity is providing a general description of the state of a person e.g., *competitiveness*, *involvement,* and such.
- **Referring to an action** - in case the entity is a description of an action, e.g., *start a business* and such.

3. Results

This section reports the results for each step of the above-described methodology. The first step, **Exact Matching**, reconnects 995 out of 1,107 skills/knowledge to ESCO. The second step, **Similarity Matching** and the third step (**Manual Revision**) recognize and link, through similarity techniques, 63 skills/ knowledge as alternative labels of those already present in ESCO, reported in Table 2.

Table 2. Skills and knowledge proposed as new alternative labels of existing ESCO concepts based on similarity matching (automatic revision). NOTE: The skills are in italic and the knowledge is in plain text. The elements highlighted with an asterisk * are not included in the new proposal as the labels partially or completely match.

Extracted concept	ESCO Skills/Knowledge Preferred Label	NEW Alternative Label proposed for existing ESCO Skills/ Knowledge
active learning	*use learning strategies*	"perform active learning"
Android	Android (mobile operating system)	*
bargaining power	*negotiate price*	*"leverage on bargaining power"*
blackboard collaborate	*collaborate through digital technologies*	*"use a blackboard to collaborate"*
complex problem solving	*solve problems*	*"perform complex problem solving"*
cooperation	*establish collaborative relations*	*"cooperate"*
critical thinking	*think critically*	*"perform critical thinking"* *"use critical thinking"* *"show critical thinking"*
data analysis software	*perform data analysis*	*"use data analysis software"*
digital databases	database	"digital databases"
Economy	economics	"economy"

Extracted concept	ESCO Skills/Knowledge Preferred Label	NEW Alternative Label proposed for existing ESCO Skills/ Knowledge
electronic mail	electronic communication	“electronic mail”
entrepreneur	entrepreneurship	“entrepreneur behavior”
entrepreneurs	entrepreneurship	“entrepreneurs behavior”
geographic information system	geographic information systems	*
google classroom	learning technologies	“google classroom”
google scholar	conduct scholarly research	“use google scholar”
Harvest	harvest crop	“harvest”
innovation	innovation processes	“innovation”
instructing	training subject expertise	“instructing expertise”
investment	*develop investment portfolio*	“*make investment*”
Learning	*use learning strategies*	*
learning strategies	*use learning strategies*	*
Linux	Kali Linux	“linux”
Loom	textile technologies	“loom”
manage risk	risk management	“techniques for managing risk”
memorization	*memorise information*	*“use memorization techniques”*
microsoft excel	*use microsoft office*	*“use microsoft excel”*
microsoft office	*use microsoft office*	*
microsoft powerpoint	*use microsoft office*	*“use microsoft powerpoint”*
microsoft teams	*use microsoft office*	*“use microsoft teams”*
microsoft word	*use microsoft office*	*“use microsoft word”*
monitoring	*monitor assessment*	*“perform monitoring”*
negotiation	*negotiate compromises*	*“perform negotiation”*

Extracted concept	ESCO Skills/Knowledge Preferred Label	NEW Alternative Label proposed for existing ESCO Skills/ Knowledge
Network	ICT network routing	“network”
online databases	database	“online databases”
Pascal	Pascal (computer programming)	*
persuasion	*moderate in negotiations*	*“leverage on persuasion”*
planning and management	*develop management plans*	*“use planning and management techniques”*
presentation software	*use presentation software*	*
productivity	*work efficiently*	*“ensure productivity in work”*
programming	computer programming	“programming”
programming languages	computer programming	“programming languages”
public speaking	*conduct public presentations*	*“perform public speaking”*
Python	Python (computer programming)	*
reaction time	*react to events in time-critical environments*	*“cope with reaction time”*
reading comprehension	*read books*	*"comprehend while reading”*
Repairing	*arrange equipment repairs*	*“perform repairing operations”*
service orientation	*focus on service*	*“ensure service orientation”*
social media sites	social media management	“social media sites”
software development tools	tools for software configuration management	“software development tools”
spatial orientation	*have spatial awareness*	*“show spatial orientation”*
Speaking	communication	“speaking”
statistical software	statistical analysis system software	“statistical software”
systems analysis	perform system analysis	*

Extracted concept	ESCO Skills/Knowledge Preferred Label	NEW Alternative Label proposed for existing ESCO Skills/ Knowledge
take responsibility	*assume responsibility*	*"take responsibility"*
technology design	*define technology strategy*	*"plan technology design"*
time management	*manage schedule of tasks*	*"perform time management"*
time pressure	make time-critical decisions	*"cope with time pressure"*
Tourism	provide tourism related information	"tourism"
value analysis	*perform asset recognition*	*"perform value analysis"*
visualization	visual presentation techniques	visualization
work together	*work in teams*	*"work together"*
working with others	*cooperate with colleagues*	*"work with others"*

The fourth step, **Definition Comparison**, leads to 15 items proposed as new concepts, in particular 13 knowledge and 2 skills, and 13 elements proposed as alternative labels of existing ESCO concepts. In addition, 11 elements could not be included as an ESCO skill, and lastly, 10 out of 49 already exist in ESCO. These results are reported in the following Tables 3, 4, 5 and 6.

In Table 3 the new skills/knowledge identified are presented with the suggested description. The new knowledge belongs mainly to the field of software, computer tools, and programming languages. The new skills are related to soft skills and educational abilities.

Table 3. Skills and Knowledge proposed as new concepts for ESCO. The following information is provided: preferred label, descriptions, and skill type.

Extracted concept	NEW Skill / Knowledge		
	Label	Description	Skills Type
atlas.ti	atlas.ti	A computer-assisted qualitative data analysis software that facilitates analysis of qualitative data for qualitative research, quantitative research, and mixed methods research. Software used for scientific research and analysis that generates deep insights from qualitative data analysis.	knowledge
bootstrap	bootstrap	Bootstrap is a free and open-source CSS framework directed at responsive, mobile-first front-end web development.	knowledge

Extracted concept	NEW Skill / Knowledge		
	Label	Description	Skills Type
data acquisition systems	data acquisition systems	The types of systems that allow one to measure or control the physical characteristics of something in the real world.	knowledge
dropbox	dropbox	File hosting service.	knowledge
educational software	educational software	Educational software is a term used for any computer software which is made for an educational purpose.	knowledge
geogebra	geogebra	Mathematics learning and teaching software that provides tools for the study of geometry, algebra and analysis.	knowledge
github	github	Provider of Internet hosting for software development and version control using Git.	knowledge
inductive reasoning	inductive reasoning	Inductive reasoning is a method of reasoning in which a body of observations is considered to derive a general principle.	knowledge
modeling software	modeling software	A computer program to build simulations or other models.	knowledge
rss	rss	RSS is a web feed that allows users and applications to access updates to websites in a standardized, computer-readable format.	knowledge
simulation software	simulation software	A program that allows the user to observe an operation through simulation without actually performing that operation.	knowledge
verilog	verilog	A hardware description language (HDL) is used to model electronic systems.	knowledge
youtube	youtube	Online tool to communicate and share video content.	knowledge
learn to learn	pursuit lifelong learning	The ability to pursue and persist in learning, to organize one's own learning, including through. effective management of time and information, both individually and in groups. This competence	skill

Extracted concept	NEW Skill / Knowledge		
	Label	Description	Skills Type
		includes awareness.	
social orientation	show social orientation	Social orientation designates how a person is aware of, relates, and adapts to other people.	skill

Table 4 presents the new alternative labels for existing skills or knowledge. For each extracted concept is indicated the preferred label of the related ESCO concept. These results can enrich the taxonomy with new ways of identifying competencies.

Some social media, such as “Instagram” and “Twitter”, were already present in ESCO as an alternative label of “use online communication tools” and in the description of “stay up to date with social media”. However, the pervasiveness of their use in many processes (e.g., to monitor customers' preferences and tendencies) leads us to suggest those concepts also as alternative labels of “stay up to date with social media”.

The concepts reported in the list are mainly related to the digital environment, indeed a lot of new alternative labels for “stay up to date with social media” and “use online tools to collaborate” have been proposed. Indeed, this can be evidence of how the changes that had affected these years were reflected in new ways of working.

Table 4. Skills and knowledge proposed as new alternative labels of existing ESCO concepts based on Definition Comparison (manual revision). NOTE: The skills are in italics and the knowledge is in plain text. The elements highlighted with an asterisk * are not included in the new proposal as the labels partially or completely match. The double asterisk ** is a wrong association, therefore it is not included in the new proposal.

Extracted concept	ESCO Skills/Knowledge Preferred Label	NEW Alternative Label proposed for existing ESCO Skills/ Knowledge
google drive	*manage cloud data and storage*	*“use google drive”*
google meet	*use online communication tools*	*“use google meet”*
ibm spss statistics	statistical analysis system software	“ibm spss statistics”
instagram	*stay up to date with social media*	*“use instagram”*
learn by doing	*use learning strategies*	*“adopt learning by doing approach”*

Extracted concept	ESCO Skills/Knowledge Preferred Label	NEW Alternative Label proposed for existing ESCO Skills/ Knowledge
mentimeter	*use online tools to collaborate*	*"use mentimeter"*
originality	*think creatively*	*"be original"*
project management software	*perform project management*	*"use project management software"*
snapchat	*stay up to date with social media*	*"use snapchat"*
twitter	*stay up to date with social media*	*"use twitter"*
ubuntu	operating systems	"ubuntu"
zoom	*use online communication tools*	*"use zoom"*

Table 5 presents the extracted concepts for which the experts involved in this task did not find any correlation with the ESCO concepts. Indeed, the differences in jargon and in the level of details of those concepts do not allow us to find out any connection.

Table 5. Extracted skills/ knowledge not associated with any ESCO skills or knowledge.

Extracted Concept	Extracted Concept
analyze	level of competition
iris	physical proximity
education	private practice
independence	competitiveness
web-based information systems	involvement
working conditions	start a business

Finally, 10 concepts have not been detected in the automatic procedure of **Exact Matching**, which used the ESCO version v.1.1.0. However, the **Definition Comparison** step, which adopts directly the ESCO portal, leads to the identification of the following items: git, google docs, latex, linkedin, myspace, prezi, skype, swift, unix, whatsapp.

5. Conclusion

There are 15 new skills, connected to existing and new job profiles. Moreover, we found 76 alternative labels of skills already included in ESCO. Table 6 contains the indicators we aimed to achieve, and the

results obtained in the actual implementation of the activities. Thanks to the use of data-driven methods, many of the indicators were largely reached.

Table 6. Indicators of objectives to be achieved within task T2.3 and actual results obtained.

Quantitative indicators	Target Value	Achieved Results
N. of new skills	15	15

Being part of such classification would be of great importance for both Education and Training providers and companies within the project. In fact, the technique developed in this document could be useful for all businesses that utilize ESCO, especially the European Commission and businesses that employ it. Our work aims to update and increase the quality of skills frameworks. Updated skills frameworks can help policymakers address the social issues that are arising from the fast evolution of new emerging trends, as in the case of Green, Digital and Entrepreneurship paradigms, as demonstrated by Spada et al. (2022c). Moreover, many firms are testing the use of ESCO as a resource of information to address various corporate matters, as described in Di Luozzo et al. (2021). In the industrial realm, having up-to-date information is even more essential than it is in the policy maker context. Our approach can help in this direction since it gives an output where skill requirements are linked very much to specific socio-technical advancement. Decision makers could gain from our findings to improve the decision-making process concerning up-skilling, re-skilling and hiring tactics. In fact, understanding the skills that will be required in the near future allows companies and policymakers to allocate their resources more efficiently based on the company's demands.

The methodological steps used in this report have also some limitations we listed in this final section of the report.

The work relies on the input of a list of extracted skills from a previous task, which may be incomplete or biased in some way. This means that the results of the work may be limited by the quality and completeness of the input data. To improve the work, the methods used to extract skills from scientific papers could be refined or additional sources of data could be used to supplement the input list.

The semantic similarity matching algorithm may not accurately measure the similarity between skills, leading to incorrect or incomplete matches. This means that the results of the work may be inaccurate if the semantic similarity algorithm fails to accurately measure the similarity between skills. To improve the accuracy, the algorithm could be refined to take into account additional factors that may be relevant to measuring the similarity between skills, such as the context in which the skills are used or the level of expertise required to perform the skills.

The manual revision process is subjective and may be prone to human error or bias, as demonstrated by Bonaccorsi et al. (2020). This means that the results of the work may be influenced by the subjective judgments of the individuals performing the manual revision process, and may be subject to errors or biases. To minimize the biases, clear guidelines could be established for the review process and multiple reviewers could be used to ensure a more objective review.

The work is limited to the skills and occupations contained in the ESCO database, and may not capture all relevant skills and occupations in the labor market. This means that the results of the work may not be comprehensive in terms of the full range of skills and occupations that exist in the labor market. To capture a more comprehensive range of skills and occupations in the labor market, the input data and

methods used in the work could be expanded to include additional sources of data or to consider a wider range of occupations.

The work is limited to the English language, and may not accurately capture the full range of skills and occupations in other languages or dialects. To accurately capture the full range of skills and occupations in other languages or dialects, the input data and methods used in the work could be expanded to include additional languages or dialects, already present in the ESCO database.

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