
AC 2011-1707: ENGINEERING IN EARLY EDUCATION: A MULTICULTURAL COMPARISON OF WEB RESOURCES

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Engineering in Early Education: A Multicultural Comparison of Web Resources

Introduction

Most efforts at reforming engineering education have concentrated at the college level, recently, the need to expand this reform to the K-12 level has received a lot of attention advancing a rapidly developing field within the discipline. In K-12 engineering education, a fundamental question revolves around identifying opportune times and approaches to introduce students to engineering, starting perhaps from the early years¹ of development. To that end, reports on K-12 engineering education from the National Academies² have raised questions about content and method appropriateness, and spotlighted ongoing efforts to understand when and how both formal and informal K-12 engineering education should take place³.

Introducing engineering in the early years raises a need to understand the content, while also posing the challenge of preparing teachers to incorporate it into their practice (10. Professional teachers, in addition to traditional methods of seeking new information in books, journals, and magazines³ also use the Internet and that has expanded how teachers receive professional development and how they prepare for practice. Use of open educational resources is popular among teachers in different countries that work in diverse educational systems. Although the Internet allows for access to curricula developed and offered for a global audience, the language in which content is presented is a barrier.

Purpose of the study

This study expands on previous efforts to identify and evaluate early education engineering web resources. Initial results were reported in a previous paper³. Our findings indicated that while considering P-12 engineering materials on the web, a wide variety of curricula, lesson plans and activities were identified. Narrowing the focus to the P-3 level though revealed that the pedagogical and content reliable sources at that level are very limited and particularly hard to identify among a plethora of information. While early engineering education is at a nascent stage and with early education teachers not yet receiving any formal preparation on the implementation of this content, this study is an attempt to identify similar resources and to investigate the existence of early education engineering curricula as created by official entities in 7 different languages used in the United States, Europe, and Asia. The study also aims to present a comparative view of the field, and offer teachers and parents interested in introducing their children to engineering, a reliable starting point towards early engineering information.

Cross-cultural Collaboration

We identified collaborators who fulfilled three criteria: (a) they were native speakers of the language they would examine; (b) they were familiar with the discipline of engineering education; and (c) they had personal experience in the educational system that officially uses the language under examination. These criteria were adopted based on our understanding that among different educational systems, and according to different educational/technological cultures, similar content might be presented using varied terminology. For example, if the English terms “PreK-12 Engineering Education Curricula” are simply translated in another language, a web search would perhaps produce different resources compared to the ones resulting from the use of the term in English. Our international group includes researchers using the Chinese, French, Greek, Korean, Spanish, and Turkish languages. Following initial discussions, each group conducted its own data collection and data analysis. When all analyses were completed, data and reports were examined in light of an international comparison. The background, method, and findings from each international group are presented in alphabetic order of searched languages, and a summary of findings and cross-cultural comparison follows.

Data Collection

English data is based on the research group’s prior work on identifying early engineering education web curricula¹. To maintain consistency, the same method was used by the international researchers and is presented in this paper as well.

To identify the content our research group was looking for, we began with a systematic Internet survey, using the following key words, “P-12 engineering curriculum” material, using the Google and Yahoo search engines. Our aim was to create a chart of engineering curricula material presently offered on the Web in relation to the age of the target group. Since the concepts and definitions regarding young engineering are very new and in order to increase the validity of the search, our sample is limited to web sites and digital material offered by universities, museums, foundations, institutions and similar entities formally recognized as relevant to educational and curriculum issues”¹

International researchers used additional keywords as well, i.e. “science”, “technology” and “innovation”, since these words appeared to make more sense and produce the engineering – related desired websites in some cultures. Previous findings have shown that although many websites claim to present P-12 content, actual content typically addresses older students, while the early educational content is barely there or absent. During the research painstaking attention was given to the content examination to ascertain which websites actually contained content targeting the early ages, and to identify the type of relevant content.

Chinese

An open internet search in Chinese was used to access publicly available resources. Preliminary results show that using “工程教育” (engineering education) or “工程师教育” (engineers' education) plus “中学/高中” (middle/high school) or “幼儿园” (kindergarten) as reference words did not result in relevant information in the field of K-12 engineering education in Chinese websites. Instead, key words such as “科学教育” (Science education) or “科学技术教育” (Science & Technology Education) provided relevant information in both science & technology education and engineering education. Therefore, in all the websites that were identified, “Science education” or “Science & Technology Education” were the main key words. Also, to limit the level of engineering education to K-12 level, the key words, “middle school”, “high school” or “kindergarten” were added to refine the search. In Chinese websites children of this age were identified as Science & Technology Education “青少年” (Youngsters). After these initial searches, “Science & Technology education” plus “Youngsters” were found to result in most relevant information searches. Other useful key words included, “科技馆” (Science & Technology Museums) and “科普”(Science Popularization). Portal links were also used to locate relevant websites.

Search using the Chinese language resulted in 9 websites containing P-12 engineering related content. Out of these 7 actually included content that targeted the P-3 level.

English

A prior survey¹ included 29 web sites, 28 American and one British. To update these findings from 2009, a new search of the web took place in September 2011 again using “P-12 engineering curriculum” as keywords, and 8 more websites were added to the list. The data was stored in a database containing information collected from the web sites and their embedded applications. Out of the 37 P-12 websites analyzed 12 actually contain P-3 level content.

French

The key words used for the search included combinations of the following French words: ingénieur (engineer), ressource pedagogiques pour l'ingenieur préscolaire (educational resources for the preschool engineer), science (science), ministere de l'éducation, technologie (technology), enseignement préscolaire (preschool education/teaching), ateliers scientifiques (scientific workshop), musee scientifiques (scientific museum), sciences a l'école (science at school), sites scolaires de sciences et technologie (scholar sites for science and technology), ressources academiques (academic resources), culture scientifique ou technologique (scientific or technologic culture), sites nationales de sciences et de technologie (National sites of

science and technology), projets scientifiques (scientific projects), projets de sciences (science projects), exposciences (science exposition) and other related terms. The search was narrowed down to include governmental organizations, universities, and museums with programs for science and engineering related education.

Findings from this search show that the term engineering education for preschool/ kindergarten education is not a formal term used in websites. A lot of activities appear under the heading of science, mathematics or technology programs for discovery, building and inventing, but have still been included in this study under this acknowledgement, since they have are considered to be engineering relevant.

Research in among French sites reported 19 P-12 websites, 17 of which included P-3 level content. The term engineering is used in various websites for example “educational resources for the young engineers”; the actual resources are activities for math, science, and building projects with the “objects of the world” (nature = enhances the creativity of the mind of the young engineer”). Furthermore engineering activities for Pre-K students were usually categorized in the term “building objects through models,” “discovering materials,” “junior builders”

Greek

In this search the researcher used the Google and the Yahoo search engines. The search started with the words “δραστηριότητες μηχανικής για παιδιά” (engineering activities for kids). This search led to just one result. The researcher, having been employed in the Greek educational system for a series of years, was familiar with the fact that the term “Τεχνολογία” (Technology), was the one main one used by the Ministry of Education Life Long Learning and Religious Affairs (MELLRA) in Greece, for this type of content in the K-12 level. In searches that followed “τεχνολογικές δραστηριότητες για παιδιά” (technological activities for kids) was used as well as a the third keyword “Επιστήμη για παιδιά” (science for kids). .

Five websites with K-12 engineering related content were identified. In regards to early education content curriculum and activities are proposed by just 1 website, and all information is presented under the terms science, math, and technology.

Korean

According to *Digest of Education Statistics 2009*⁶, Korea was the country that had the highest percentage (25.4%) of bachelor’s degrees in engineering among the 29 OECD countries in 2006. However, like the other countries, engineering in Korea is a discipline for college students, so the term, *engineering education*, is used for college level and rarely applied to P-12 education. Thus, a lot of engineering activities for P-12 students fall under the umbrella of science education, creativity, or invention.

Initial online searches for resources in P-12 engineering curricula were conducted through popular Korean search engines, such as NAVER (www.naver.com), Yahoo! Korea (www.yahoo.co.kr), and Google Korea (www.google.co.kr). The key words used for the search included combinations of the following Korean words: “공학” (engineering), “과학교육” (science), “기술” (technology), “유아교육” (early childhood education), “초등교육” (elementary education), “중등교육” (middle school education), “고등교육” (high school education), “쌓기” (block building), “기계” (machines), “도구” (tools), “발명” (invention), and various Korean terms, e.g. “수업계획안”, “수업계획서”, “강의 계획서”, “수업 지도안”, “활동자료”, “세안”, “범안”, “일일계획안”, “주간계획안”, “연간계획안”, “교육계획안” (meaning curricula, lesson plan, and activities). However, hundreds of Korean commercial websites pop up first and limited effective searching efforts. Thus, the second attempt of searching was conducted by visiting websites created by credible organizations, such as government research institution or foundation, museum, and universities that run programs for science and engineering related education. If searched websites lead to other related websites, all the related websites were visited to check the existence of engineering curricula, lesson plans, and activities.

A total of 35 websites were found to have P-12 engineering content. Among them, 32 websites contain content for the P-3 level. Engineering activities for Pre-K students were usually categorized in the terms, such as *building blocks*, *transportation*, *simple machines*, and *tools*. Furthermore, even though various engineering lesson plans and scattered activities were found, no engineering curricula existed.

Spanish

Searches for online resources for P-12 engineering curricula in Spanish were carried out through Google and Yahoo search engines. Initial searches started by using the terms, “*educacion en ingenieria*” (engineering education), “*materiales curriculares de educacion en ingenieria*” (engineering education curriculum) and combining these two terms with words, such as “*pre-escolar*” (preschool), “*primaria*” (elementary), “*secundaria*” (middle school), and “*preparatoria*” (high school). This initial search resulted mostly in description of academic engineering programs; therefore a second targeted search of official websites belonging to educational organizations (e.g., websites containing information about educational standards) was conducted in order to be able to identify the term used for this area of education. The term most commonly used related to engineering was “*ciencia y tecnologia*” (science and technology) or “*ciencia aplicada*” (applied science).

The second round of searches started using the phrase: *science* and *technology* and resulted in a set of resources that were further examined. One of the most common findings resulting from this second search was related to websites that described how to use or integrate “tecnologias de informacion” (information technology) into educational settings. These results were discarded from the analysis. Websites that were also discarded from the analysis were those that only focused on science (e.g., were only focused on classroom experiments). A total of 9 websites were found to have engineering content, but 3 of them were discarded because they did not meet the criteria of being created by an official institution. Out of the 9 websites, only 1 actually contained P-3 level content. None of the websites were aligned to any specific curriculum or educational standards, none of the materials showed evidence of having been assessed or field tested, and none of the materials contained classroom assessment materials.

Turkish

Engineering education in Turkey has recently received attention from both the academic community and industry. The first academic engineering education conference was gathered in 2010 (International Engineering Education Conference). This conference encompassed most areas of engineering, but very little material (papers, workshops, panels) was on K-12 or pre-school related. A review of the conference proceedings revealed that only one workshop was focused on elementary education⁹. The focus of the workshop was directly related to engineering education and focused on math science and technology education via engineering practices.

In an effort to profile websites related to engineering at the P-12 level, web searches using different search engines (Google, Yahoo, and Bing) were conducted. The search terms included “muhendislik” (engineering), “egitim” (education), “fen bilimleri” (science), “matematik” (mathematics), “okul oncesi” (early childhood), “bulus” (invention), “program” (curricula), “aktiviteler” (activities), and “teknoloji” (technology). Later, the search was expanded using Boolean methods and terms like “math education”, “science education”, and “*physics* education” were explored. The collection of results is presented in the following table. Although 18 websites were identified, just 1 referenced below refers to “*engineering*” or “*engineering education*”. Most of the web sites do not refer to engineering education directly but might include some activities related to science where engineering concepts are used. Nine websites contained P-3 level content.

Findings

Based on the data collection, a summary chart (see Figure 1) compares the number of open resources that contain engineering related web-content targeting P-12 students in each language. Since each country using one of the searched languages has different infrastructure for the use of web resources, and varied emphasis on P-12 science, technology, mathematics, and engineering education, the number of websites might be confounded by this fact. However, in the spite of the

disparity, the results of this study reveal the current landscape of engineering education for P-12 students in the countries using the corresponding languages. In parallel to that summary the existence of content actually targeting P-3 education is presented (see Figures 1 and 2).

According to this analysis, there seems to be a big diversity both when it comes to the actual number of engineering related web-resources available among different languages, but also to the emphasis that seems to be given among these different cultures to addressing the early ages, based on the percentage of the websites that present P-3 content among each language.

The type of content that was presented through the web-sites has also been analyzed (see Figures 3 and 4). In all languages, individual activities seem to be the most common type or resource to encounter, followed by lesson plans, while comprehensive curricula are rare. At the P-3 level resources seem to mainly comprise of individual activities, with rare lesson plans or full curricula.

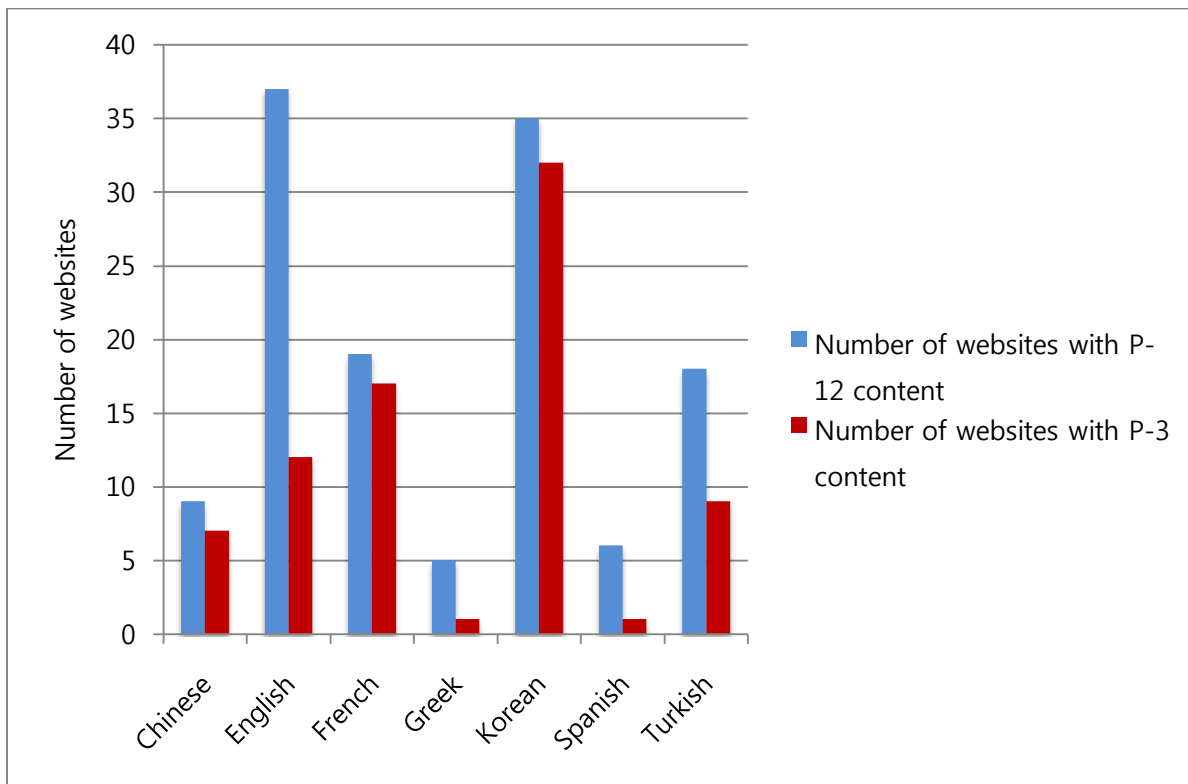


Figure 1: Cross-cultural comparison of the number of websites that contain P-12 and P-3 engineering content.

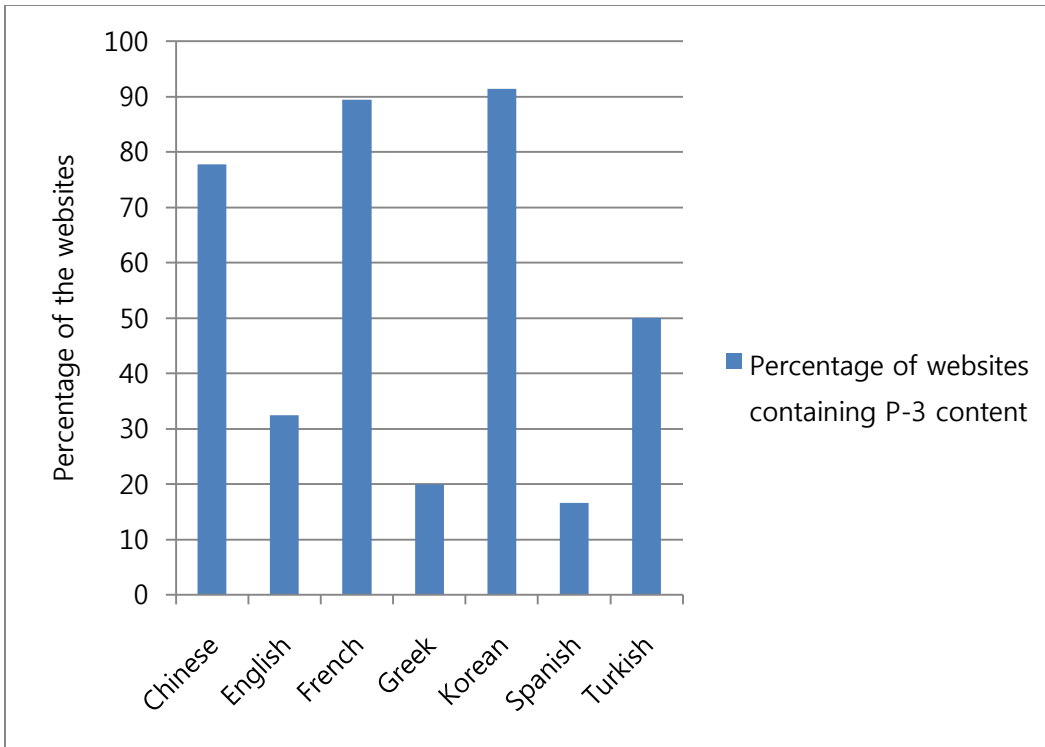


Figure 2: Percentage of the websites containing P-3 engineering related content per language.

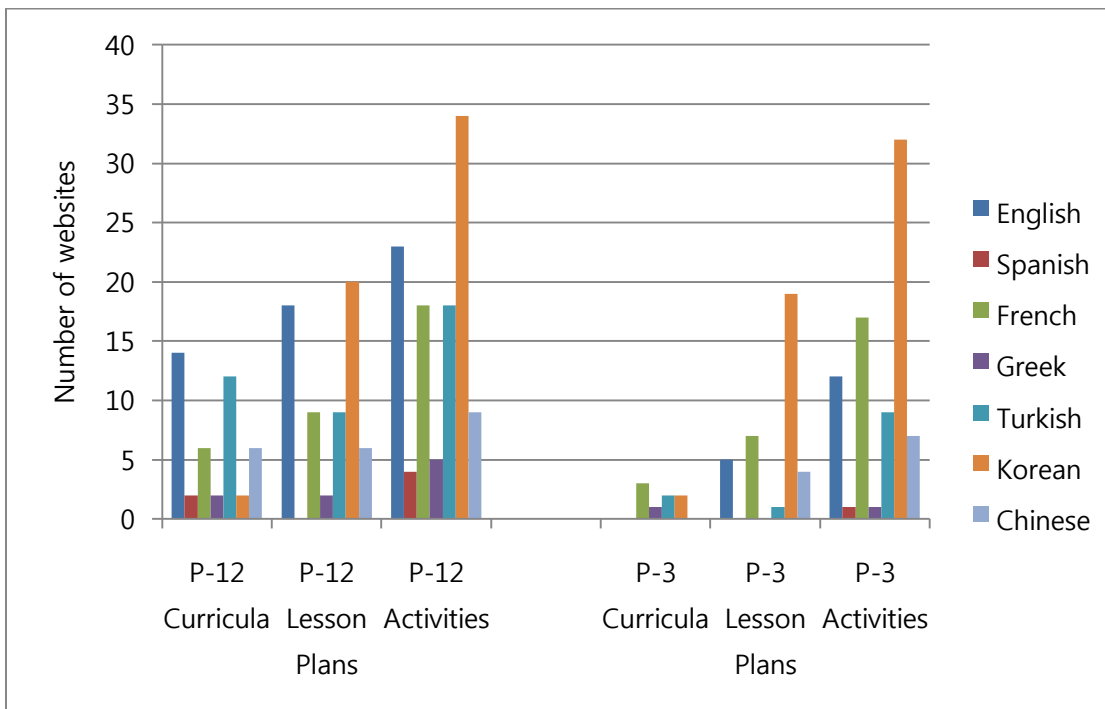


Figure 3: Number of websites presenting engineering related curricula, lesson plans and activities.

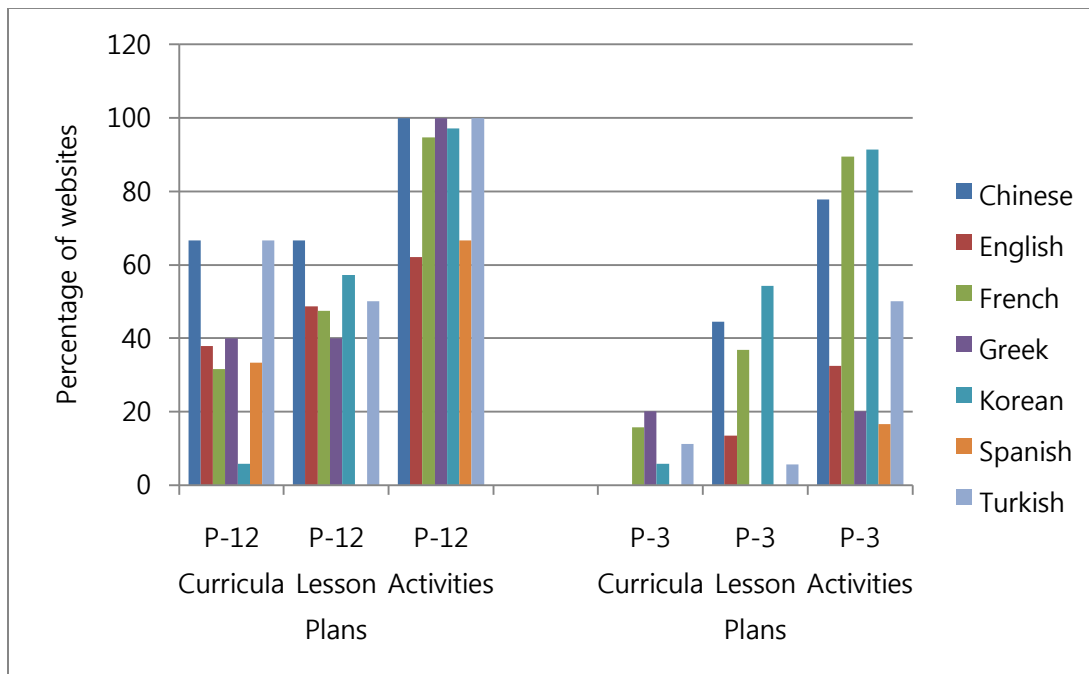


Figure 4: Percentage of websites presenting engineering related curricula, lesson plans and activities.

Discussion

Based on the analysis of the searched websites' content in each language the following conclusions are reached. When considering early education engineering related resources, Korea appears to be the country that has developed the most web resources, followed by French speaking countries. English web-resources appear to have a strong presence in the P-12 level, but when it comes to addressing the early education level, they seem to be significantly less. These results should be understood under the following caveat: while looking for P-12 "engineering" content, non-English websites revealed almost no results so additional terminology had to be used, a fact that has led to more websites identified, allowing us to hypothesize that more English websites could have been identified had additional terminology been used for the English search as well. China and Turkey appear to be diametrically positioned with regards to the English case since, although they do not have many resources developed yet, they show a tendency towards addressing young ages. Greek and Spanish appear to be the two languages that neither have a big number of websites with engineering relevant content developed, nor do websites presenting P-3 content have a strong presence among the already existing ones. Keeping these findings in mind, and considering the size of the population these languages represent respectively, it makes it safe to come to the conclusion that, although the advent of internet has made educational content globally available, the language barrier is a significant one

to overcome and currently deprives single language users and teachers from taking full advantage of available content.

Cross-cultural findings regarding the type of content remain consistent with the group's prior research findings based on the English websites' analysis. Most comprise of individual activities; more organized lesson plans or long-term curricula are harder to find, if at all. Expanding an improving the available early engineering web based material is well under way in multiple contexts, languages and cultures. The high level of activity, the interactive nature of the medium, the global desire for integration will surely be positive forces in improving the quality of available resources thus facilitating teacher access and adaptation of early engineering content in the K-12 engineering education in schools.

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