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3 **Innovative Curriculum Strategies for Managing the Future of Food Science, Technology and**
4 **Engineering Education**

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17 **Abstract**

18 The rapid advancement of science and technology, driven by digitalization and artificial intelligence,
19 underscores the need to reevaluate food science, technology, and engineering (FST&E) education. A
20 global study with 688 respondents examined key challenges and opportunities in this evolving field,
21 gathering input from professionals and students in Africa, China, Eastern and Western Europe, USA &
22 Canada, and South America & Mexico. The study aimed to identify strategies such as hybrid teaching,
23 project-based learning, interdisciplinary collaboration, and internships to meet future educational
24 demands. Principal Component Analysis highlighted two key factors: professional development (PC1),
25 which grouped adaptability, employability, soft skills, and apprenticeships; and future-oriented
26 education (PC2), clustering hybrid teaching, curriculum revisions, nutrition integration, and research
27 projects. African participants placed greater emphasis on these factors compared to USA respondents.
28 A notable finding was the lower engagement of food engineering (FE) professionals with both principal
29 component factors compared to their food science and technology (FST) counterparts. This suggests a
30 possible resistance to change or higher satisfaction with the status quo, which could limit FE
31 professionals' ability to meet future business and innovation requirements. This is concerning given
32 the rapid technological and science progress and the necessity for new curricula that foster innovation.
33 The study underscores the importance of adapting FST&E education to regional differences and
34 evolving industry expectations. It advocates for strategic educational transformations that integrate
35 emerging technologies, interdisciplinary approaches, and practical learning opportunities to equip
36 students for future challenges and capitalize on new opportunities in the FST&E field.

37 **Keywords:** Professional development, Future innovative education strategy, Adaptability, Nutrition
38 integration, Food Science, Technology & Engineering

39 **Paper type:** Research paper

40 **Short Title:** Strategies for Evolving Innovative Food Education Curricula

41 1. Introduction

42 The rapid advancement of science, technology, and innovation, propelled by the proliferation of
43 computerized capabilities and artificial intelligence (AI), underscores the urgent need to evaluate the
44 landscape of food science, technology, and engineering (FST&E) education. This imperative is
45 accentuated by the advent of the fourth industrial revolution, known as Industry 4.0, marked by
46 significant strides in various technologies including AI, smart sensors, robotics, blockchain, and the
47 Internet of Things (IoT). Emerging food trends such as fortified and functional foods, additive
48 manufacturing technologies, cultured meat, precision fermentation, and personalized nutrition
49 intersect with the innovations of Industry 4.0, necessitating a comprehensive review (Hassoun et al.,
50 2024). Critical emerging breakthroughs to be considered are quantum computing and AI, promising to
51 redefine the boundaries of technology and business (How and Cheah, 2023), will probably also reshape
52 the domain of food, nutrition and health.

53 Recent studies have illuminated the potential applications of AI in food manufacturing technologies,
54 alongside anticipated challenges and solutions (Chen et al., 2020; Hassoun et al., 2024; Kler et al., 2022;
55 Yu et al., 2024). For example, the transformative impact of AI in education has been underscored,
56 mirroring its broader influence across industries (Allen and Kendeou, 2024; Gao and Lv, 2017; Turner
57 et al., 2024). Disruptions such as digital agriculture, the fourth industrial revolution (industry 4.0),
58 innovation agility, big data, and AI have been utilized to characterize the changes in the way agro-food
59 systems evolve and function, as well as in the approach they have been analyzed, measured, and
60 monitored (Chapman et al., 2022).

61 Other industries, such as the chemical industry, are embracing the broad adoption of AI and machine
62 learning (ML) methods. A holistic view of how the industry is transforming digitally towards AI used to
63 aid humans in better decision-making, followed by state-of-the-art AI research addressing industrial
64 needs on reliability and safety, process optimization, supply chain, material discovery, and reaction
65 engineering were highlighted. Finally, a vision of the planet of the future is illustrated with critical
66 components of AI-ready culture, model life cycle management, and the renewed role of humans in
67 chemical manufacturing (Chiang et al., 2022). The application of (AI) is rapidly transforming various
68 other industries, and the pharmaceutical industry is no exception (Khan et al., 2023).

69 Future industry needs, including new enabling technologies (e.g., big data, IoT, cloud computing, digital
70 twins, machine learning, virtualization) (Erdogdu, 2023), require the development of new education
71 programs and skills. For instance, Wageningen University, one of the leading influential universities,
72 has taken an active strategy to align with the developments in IT and AI. Apart from the content-wise
73 shift, skills such as critical thinking, creativity, and problem-solving are addressed by applying project-

74 based pedagogies (Catal and Tekinerdogan, 2019). Additionally, Food science and technology (FST) and
75 especially food engineering (FE) in academia had been faced with diminishing funding for research,
76 dwindling critical masses in faculties (particularly at universities in the USA) and impacting future
77 cooperative extension education and research needs (Donaldson et al., 2022).

78 FST&E professions are witnessing significant challenges as well as changes imposed by the accelerated
79 rate of change and digital transformation. The expected changes will most probably affect FST&E
80 education as already projected (Adedeji, 2020; Aguilera and Moreno, 2021; Castello et al., 2023;
81 Karabulut-Ilgu et al., 2018; Medina et al., 2019; Niranjana, 2016; Saguy et al., 2018; Saguy et al., 2024;
82 Singh and Erdogdu, 2004; Society of Food Engineering (SoFE), 2019; Viaggi et al., 2021).

83 In light of these mounting challenges, education programs for food science, technology, and
84 engineering (FST&E) were considered (Aguilera and Moreno, 2021; Epriliati, 2024; Saguy et al., 2024;
85 Serhan and Yannou-Lebris, 2021) as well as for chemical engineering (Chintalapati et al., 2024; de
86 Reviere et al., 2024; He et al., 2024; Lavor et al., 2024; Samsuri and Osman, 2024). Utilizing a global
87 survey targeted professionals and students across food disciplines and nutrition to evaluate the status
88 of FST&E higher education, identify opportunities, and provide recommendations for possible future
89 curricula were recently assessed and **three** main conclusions were drawn (Saguy et al., 2024): 1. Critical
90 areas for future curricula - Seven key topics were identified as highly important for the future of FST&E
91 curricula, including critical thinking, problem-solving projects, teamwork/collaboration,
92 innovation/open innovation, and multidisciplinary approaches. These areas are deemed essential for
93 preparing students to navigate the complexities of the modern food industry and address emerging
94 challenges. 2. Significance of academic partnership and collaboration - The importance of collaboration
95 between academia and the food industry, as well as with nutrition sciences, was underscored. The
96 food industry plays a significant positive role in collaboration and partnerships, offering opportunities
97 such as internships, education, and strategic vision. Integration between FST&E and nutrition sciences
98 is highlighted as crucial, especially in response to growing consumer awareness of health and wellness.
99 And 3. Education curricula paradigm shift - The need for new avenues to better meet the expectations
100 of future graduates and students was highlighted. Insights into novel education and learning
101 opportunities, as well as new topics for future curricula, have been identified, indicating a potential
102 shift towards more holistic and interdisciplinary approaches in FST&E education.

103 The primary aim of this study was to pinpoint innovative strategies—such as hybrid pedagogical
104 approaches, project-based learning methodologies, interdisciplinary initiatives, collaborative
105 partnerships, and internship programs—that are indispensable for addressing the evolving educational
106 demands of the future. This objective was achieved by employing statistical methodologies for

107 comprehensively exploring the future trajectories of FST&E curricula on a global scale and within
108 individual educational nations.

109 **2. Methods**

110 **2.1. Research design**

111 A structured questionnaire was employed, building upon prior research approaches outlined
112 previously (Saguy and Cohen, 2016; Saguy et al., 2024).The questionnaire targeted global
113 professionals, including students, in the fields of food science, food technology and food engineering
114 (FST&E), nutrition, and related disciplines. *The respondents were allowed to make their own main
115 professional field selection.* Qualtrics *software XM (Version September 2022, Qualtrics, Provo, UT,
116 USA. <http://www.qualtrics.com/>).* It aimed to reflect the professional values held by individuals in the
117 aforementioned fields and geography. Prior to the main survey, a pilot test was conducted with 12
118 food *experts* from academia and industry to ensure questionnaire consistency and incorporate
119 improvement suggestions. The pilot data was excluded from the final analysis.

120 The questionnaire's web link was distributed to professionals worldwide via email by various
121 organizations, including *the International Union of Food Science and Technology (IUFoST), the
122 Institute of Food Technologists (IFT) and ISEKI Food Association.* The survey was conducted in
123 English to mitigate language ambiguities and was entirely anonymous.

124 Respondents used a 5-point Likert-type scale (ranging from 1 ('Very low'), 2 ('Low'), 3 ('Medium'), 4
125 ('High') and 5 ('Very high')). For comparisons, the Likert-type scale assessments were transformed into
126 a calculated average. The Likert-type scale is a widely recognized psychometric tool extensively
127 employed in educational and social sciences research, marketing studies, customer satisfaction
128 assessments, and similar applications. Additionally, demographic information, such as gender and age
129 group was collected. Education segmentation was derived based on the geographic site where the
130 highest degree was attained (not to be confused with a person's current site of living) or the current
131 location for students. The education segments were collected across Western Europe and the UK,
132 Eastern Europe, Africa, *USA* & Canada, South America & Mexico, Asia/Middle East, China, Far East &
133 Oceania (Australia, New Zealand). The questionnaire concluded with an open-ended query soliciting
134 suggestions for curriculum enhancements.

135 **2.2 Statistical analyses**

136 Data analysis was performed using *MS Excel for Windows (Microsoft Corporation, Redmond, WA,
137 2021)* and *SPSS 29 (IBM Corporation, LLC, Armonk, NY, 2023)* employing one-way Analysis of Variance
138 (ANOVA) and Principal Component Analysis (PCA).

139

140 **2.3 Participants**

141 The total number of respondents who started the questionnaire was 1022. Out of these, 703
142 completed the survey (Saguy et al., 2024). The PCA analysis revealed 15 outliers, which were
143 subsequently removed, resulting in 688 (67.3%) respondents. It is important to note that all
144 respondents who left one or more questions unanswered or were identified as outliers were excluded
145 from the analysis. The survey took approximately 10 to 12 minutes to complete.

146 **2.4 Ethics**

147 The survey was written according to the authorization from the Committee for the Use of Human
148 Subjects in Research through The Robert H. Smith Faculty of Agriculture, Food and Environment of The
149 Hebrew University of Jerusalem (file: AGHS/01.15) as outlined previously (Saguy et al., 2024). The
150 participants were informed that their responses would be completely anonymous and their consent
151 was requested before starting the questionnaire. Participation was voluntary, and their explicit
152 consent was requested. Only those who voluntarily agreed were permitted to participate. This study
153 includes new and distinct data.

154

155 **3. Results and discussion**

156 **3.1. Demographics and education geographic sites**

157 Table 1 presents the panel demographic data. The data showed **quite** similar distributions among
158 gender (female/male 53.2 vs. 45.5%, respectively) and age groups (excluding the 18–25 years group,
159 7.4%). The age distribution indicates good participation of the various groups and experiences. On the
160 other hand, the lower representation of students is not surprising **due to a lower availability of e-**
161 **mail addresses.**

162

Insert Table1 about here

163 The distribution of the educational geographical regions indicated a good global presence; however,
164 as expected, some regions were more prevalent than others. For instance, the number of respondents
165 from China, the Far East, and Oceania was relatively low (4.2%). Quite surprising was the high number
166 of respondents from Africa (14.6%), probably due to the **high number of e-mail addresses provided by**
167 **the IUFoST and the participants willingness.** Table 1 indicates that the study also included other
168 adjacent food related professions (181, 26.3%) closely related to FST&E (i.e., microbiology, nutrition,
169 chemical engineering, bioengineering/biotechnology, business/marketing).

170 **3.2. Curricula future topics shaping the professional domain**

171 Initially, the respondents evaluated, using the Likert-type scale the importance of 9 topics for possible
172 inclusion in curricula for meeting future challenges and learning opportunities (Table 2). Topics
173 assessment scoring an average of 4.0 ('High') or above on the Likert-type scale were: 'Research
174 projects', 4.34 ± 0.71 (mean \pm standard deviation), followed by 'Apprenticeships (e.g., industrial
175 training)', 4.31 ± 0.71 , 'Adaptability', 4.23 ± 0.75 , 'Revision of the current education program', $4.20 \pm$
176 0.75 , and 'Employability', 4.14 ± 0.80 . The other 4 topics were assessed somewhat lower (<4.0);
177 nevertheless, their assessment was quite high as could be seen by their calculated average that was
178 quite close to 4.0: 'Enhanced integration with nutrition' 3.98 ± 0.81 , 'Business related (e.g., creation,
179 network, partnership, collaboration)', 3.93 ± 0.88 , 'Soft (life) skills', 3.91 ± 0.84 , and 'Hybrid (remote
180 and frontal) teaching', 3.83 ± 0.87 . These values differ slightly from those reported previously (Saguy
181 et al., 2024) due to the aforementioned exclusions of outlier respondents (i.e., $n=688$ vs. 703,
182 respectively).

183 To further delve into the effect of educational segmentation, segmentation analyses were carried out
184 in order to gain insights into the differences between the relevance of topics affecting the future of
185 professional curricula based on geographical locations. This approach assumes that all respondents
186 were homogeneous concerning their perceptions of the importance of the topics. Different segments
187 of respondents, however, may have different values that can affect their perception of the other topics
188 for future curricula. Therefore, it is assumed that segmentation by the education country/continent
189 might show insight into the differences between respondents concerning their perception of the
190 importance of the topics for future curricula.

191 For example, Table 2 shows that participants from the African region rated all nine education topics
192 above 4.0 on a Likert-type scale. Some topics, such as 'Research project(s)' and 'Apprenticeships (e.g.
193 industrial training)', received very high scores of 4.63 and 4.55, respectively. On the other hand, China,
194 Far East & Oceania region had the lowest average score of 3.93 for all nine topics.

195 'Enhanced integration with nutrition' was considered the least important for the USA & Canada
196 education region (3.50, Table 2). The need for integration with nutrition has been highlighted
197 previously (Onyeaka et al., 2023; Saguy et al., 2018; Saguy et al., 2024; Yu et al., 2024) and most
198 probably will be adopted in future curricula.

199 For Western Europe & UK education segment, 'Hybrid teaching', 'Enhanced integration with nutrition',
200 and 'Business-related (e.g., creation, network, partnership, collaboration)' topics were the least
201 important. For China, Far East & Oceania segment, 'Business-related (e.g., creation, network,
202 partnership, collaboration)', 'Employability' and 'Soft (life) skills' were the least important. This may
203 indicate that these topics are determined by external factors such as the universities and/or state and

204 the respondents may have no real say. However, due to the small number of participants in this
205 segment, this conclusion needs further verification.

206 **Insert Table 2 about here**

207 The respondents ranked 'Revision of current programs' and 'Employability' as high priorities, with
208 averages of 4.20 and 4.14, respectively). These assessments hold important implications for academic
209 programs seeking to adapt to the rapid changes driven by innovation, disruption, and digital progress,
210 as also previously highlighted (Saguy et al., 2024). The 'Revision of current programs' is an excellent
211 opportunity to incorporate various applications of AI in food related studies alongside anticipated
212 challenges and solutions (Chen et al., 2020; Hassoun et al., 2024; Kler et al., 2022; Yu et al., 2024).

213 Adaptability encompasses qualities like flexibility, innovation, openness, and resilience, which are
214 especially crucial in unforeseen circumstances. Key aspects of adaptability include confidence
215 combined with receptiveness to criticism, a focus on solutions over problems, collaborative skills, and
216 learning from others (<https://www.walkme.com/glossary/adaptability/>). Adaptability can also be
217 viewed as the capacity of educational systems to respond effectively to evolving conditions while
218 upholding stability, fostering equality, and enhancing overall well-being. Important components of
219 educational adaptability include cooperation, inclusivity, and flexibility (Green et al., 2020). Therefore,
220 strategies for fostering personal and educational adaptability should be carefully considered and
221 implemented.

222 Employability stands out as a critical attribute in higher education. Universities place significant
223 emphasis on employability as a primary goal of personal and public investment in higher education,
224 targeting graduate employability across their teaching, learning, assessment, and student support
225 frameworks. Despite its growing importance, graduate employability currently lacks a coherent and
226 robust theoretical or pedagogical foundation (Healy, 2023). Effective employability should encompass
227 entrepreneurial training that equips students with the skills necessary to develop marketable and
228 profitable solutions to emerging challenges (Healy, 2023). Open innovation, collaboration, and
229 partnerships are integral components in fostering this type of preparedness. The data underscores the
230 respondents' recognition of these priorities, emphasizing the imperative to incorporate these vital
231 aspects into strategic planning for future curricula.

232 Future planning of the revised curricula should address FST&E professions' significant future challenges
233 imposed by the accelerated rate of change and digital transformation as was also previously projected
234 (Adedeji, 2020; Aguilera and Moreno, 2021; Castello et al., 2023; Karabulut-Ilgü et al., 2018; Medina
235 et al., 2019; Niranjan, 2016; Saguy et al., 2018; Saguy et al., 2024; Singh and Erdogdu, 2004; Society of
236 Food Engineering (SoFE), 2019; Viaggi et al., 2021).

237 **3.3. Education region impact on professional expectations of ‘Success’, Satisfaction’ and ‘Meeting**
238 **expectations’**

239 The impact of the respondents’ education region on their perceived professional ‘Success’,
240 ‘Satisfaction’, and ‘Meeting expectations’ is depicted in **Figure 1**.

241 **Insert Figure 1 about here**

242 Overall, the education region showed significant statistical differences only between the perceived
243 importance values for ‘Success’ (mean=4.04) and ‘Meeting expectations (mean=3.76) but not with
244 ‘Satisfaction’ (mean=3.99) (one-way ANOVA with post-hoc LSD test, $p < 0.05$). ‘Success’ was not
245 significantly different from ‘Satisfaction’. ‘Meeting expectations’ significantly differed from ‘Success’
246 and ‘Satisfaction’ (one-way ANOVA with post-hoc LSD test, $p < 0.05$). The overall lower values obtained
247 for ‘Meeting expectations’, probably project the respondents’ perceived importance of the need for
248 curriculum improvements.

249 However, when comparing the individual perceived importance values of the educational region,
250 significant differences were observed (one-way ANOVA with post-hoc LSD test, $p < 0.05$). For instance,
251 the perceived ‘Success’ values of Western Europe & UK (4.00) were significantly lower as compared
252 with **USA** & Canada participants (4.23) or Asia & Middle East (4.24). **USA** & Canada (4.23) respondents
253 perceived importance was also significantly higher when compared with Eastern Europe (3.80), South
254 America & Mexico (4.10), China, Far East & Oceania (3.83). It is worth noting that the high perceived
255 importance values were obtained both in **USA** & Canada and Asia & Middle East as compared with the
256 lowest values for Eastern Europe and China, Far East & Oceania. These significant differences call for
257 more elaborate studies in order to better understand what drives these contrasts. It is quite possible
258 that future curricula differences play a role among additional factors that were not studied.
259 Nevertheless, these identified differences could open new avenues for education institutes to conduct
260 in-depth assessments of their alumni and graduates, focusing on improving their programs to enhance
261 their future educational performances in order to better meet their graduates’ future success. Several
262 specific future curricula topics were listed above.

263 When comparing the effect of educational region on ‘Meeting expectations’, average values ranged
264 between 3.52 to 3.98 with a total average of 3.75. Several significant differences (one-way ANOVA
265 with post-hoc LSD test, $p < 0.05$) were observed. For instance, Western Europe & UK (3.83) with Africa
266 (3.52), Eastern Europe (3.60) with **USA** & Canada (3.98), Africa (3.52) with **USA** & Canada (3.98), and
267 Asia & Middle East (3.81). The relatively lower values obtained for ‘Meeting expectations’ clearly
268 project the potential for improvement and call for possible future considerations as was also
269 recommended previously (Saguy et al., 2024).

270 3.4. Principal Component Analysis (PCA)

271 Conventional statistical methods like comparing means may fall short in discerning nuanced similarities
272 and distinctions and effectively differentiate among segments. Therefore, Principal Components
273 Analysis (PCA) with Varimax rotation and Kaiser Normalization for perceptual segmentation mapping
274 was utilized (Timmerman et al., 2007). The PCA components with eigenvalues exceeding 1.0 were
275 extracted and subsequently rotated using the Varimax method with Kaiser Normalization to achieve
276 an orthogonal structure. Worth noting that (PCA) is the technique that removes dependency or
277 redundancy in the data by dropping those features that contain the same information as given by other
278 attributes. and the derived components are independent of each other by themselves with a single
279 variable.

280 Two Principal Components (PC1 and PC2), accounting for 48.6% of the overall variance, were
281 identified. To better understand the elements that construct PC1 and PC2, their loadings were derived
282 and are detailed in [Table 3](#) (only factor loadings above 0.4 are presented).

283 **Insert Table 3 about here**

284 PC1 accounts for 28.1% of the total variance, and it encompasses 5-key topics, namely: 'Adaptability',
285 'Employability', 'Business related (networking, partnership, collaboration)', 'Soft (life) skills', and
286 'Apprenticeships' ([Table 3](#)). PC1 aggregates aspects of perceived importance for future business-
287 related skills and open innovation and can be classified as 'Professional development'. It could reflect
288 the ongoing process of acquiring and honing skills and qualities that enhance one's career readiness
289 and effectiveness in the workplace.

290 PC2 contributes 20.5% of the total variance, and amalgamates 4-key topics, namely: 'Hybrid teaching',
291 'Revision of the current education programs', 'Enhanced integration with nutrition' and 'Research
292 project(s)' ([Table 3](#)). It can be grouped as 'Future innovative education'. This term integrates the
293 essence of hybrid teaching, revising current education programs, enhancing integration with nutrition,
294 and engaging in research projects. It probably signifies a modern approach to education that combines
295 technology, curriculum updates, holistic development (including nutrition), research-based learning
296 methodologies, and evolving educational landscape, emphasizing adaptive teaching methods,
297 curriculum enhancements, nutritional awareness, and a stronger emphasis on research initiatives.
298 These topics are at the core of FST&E education and indicate the need to update the current curricula.

299 **Insert Figure 2 about here**

300 [Figure 2](#) presents the conceptual map location of the education regions with regard to PC1 and PC2.
301 The data clearly highlight the location differences among the various educational regions studied. For

302 instance, FST&E members who graduated or are currently studying in Africa yielded the highest PC1
303 and PC2 values and are located remotely higher than all other geographical educational zones tested.
304 It is clear that these respondents perceived 'Professional development', and 'Future innovative
305 education' as very important. It is also possible that adopting these future education directions will
306 improve their 'Satisfaction' and 'Meeting expectations' perceptions, which were quite low among all
307 the other regions tested (see Figure 2).

308 On the other hand, USA & Canada relatively low value of PC2 could probably project their reluctance
309 to change as they are content with their perceived 'Success', 'Satisfaction', and 'Meeting expectations'
310 importance as their data show (Figure 2).

311 China, Far East & Oceania are positioned on the left side of the map indicating a low value of perceived
312 'Professional development' importance. As the number of respondents for this educational segment
313 was quite low, the data is insufficient to be utilized for making concrete conclusions. Nevertheless, it
314 shows a perceptual direction for the need to improve their 'Professional development' that probably
315 will improve their quite low 'Success', 'Satisfaction', and 'Meeting expectations' (see Figure 2).

316 Figure 3 depicts the PCA map of FST, FE, and the other adjacent professions (such as microbiology,
317 nutrition, chemical engineering, bioengineering/biotechnology, business/marketing, and consulting).
318 It highlights that FST and FE are located in opposite directions. While FST is more positive on both
319 'Professional development' and 'Future innovative education', FE is located on negative values. It is
320 quite possible that FE are less open to change and are not reacting positively to changes in the
321 curricula.

322 **Insert Figure 3 about here**

323 The fact that both FST and other professions are located close to the origin is explained by the
324 contributions of the various education regions that are averaging the importance of the possible
325 curricula changes as highlighted also in Figure 2. Hence, it is safe to conclude that tailored made
326 programs are required.

327 The reluctant indication of a change of the FE is interesting. Figure 4 (a and b) highlights that the major
328 resistance is due to USA & Canada educated participants. This indicates that the 9 topics tested
329 focusing on possible curricula changes were not perceived as very important. This could be due to
330 several factors; for instance, the current program is satisfactory, less familiarity and interest in
331 innovation and change, content with the status quo, and many others. It could also indicate that future
332 changes in FE curricula would be more difficult.

333 **Insert Figure 4 about here**

334 Figures 4a and 4b depict the effect of the various education regions on both FST (a) and FE (b). It is
335 quite obvious that the African participants are located quite differently from the other regions. For
336 both FE and FST, 'Professional development' and 'Future innovative education' the high values indicate
337 that these are very important attributes and should most probably be included in the curricula. It is
338 expected that changes along in these directions will be most welcome and supported by the FST and
339 FE alike. On the other hand, FST respondents who were educated in China, Far East & Oceania are on
340 the far left of PC1 indicating less importance to 'Professional development'; this resistance is declining
341 for FE. It should be noted that the number of participants from this zone was quite small, therefore,
342 these data should be taken with a grain of salt.

343 Another interesting observation is the differences between FST and FE professionals (as also shown in
344 Figure 3). While FST are more open to future innovative education, FE are reluctant to changes either
345 because they consider that current curricula as satisfactory, content with the status quo, and/or
346 resistant to innovation due to their specific programs that are focusing more on mathematics and
347 transport phenomena rather than innovation and business oriented. This could become a real issue
348 requiring in-depth FE internal discussion, as the innovation changes are accelerated and future
349 demands and job requirements are everchanging.

350 FST participants who were educated in the USA & Canada are located on the lowest value of 'Future
351 innovation education', while FE professionals from the same zone are located on the lowest value of
352 'Professional development'. This indicates that these professionals are quite satisfied with the current
353 education program, being in their comfort zone, and consequently reluctant to consider changes. Their
354 high satisfaction of their education program is also depicted in Figure 1.

355 **4. Conclusions**

356 The rapid evolution of science, technology, and innovation, driven by the expanding reach of digital
357 capabilities and AI, underscores the critical imperative to assess the future landscape of curricula in
358 FST&E. This study investigates avenues for enhancing curriculum content and strategies to adapt
359 FST&E education for forthcoming changes across diverse educational settings. It achieves this by
360 analyzing respondents' perceptions of the importance of nine key topics, including 'Revision of the
361 current education programs', 'Hybrid (remote and frontal) teaching', 'Apprenticeships (e.g., industrial
362 training)', 'Enhanced integration with nutrition', 'Research project(s)', 'Soft (life) skills', and
363 'Employability'. Educational segmentation of respondents reveals significant disparities among various
364 educational sectors. This study proposes potential explanations, yet additional in-depth interviews are
365 essential to validate and comprehensively explore the underlying reasons for these differences.

366 Subsequently, this research aims to develop actionable strategies to implement impactful educational
367 programs in FST&E.

368 Food engineering (FE) participants showed distinctly lower values of both PC1 and PC2 In comparison
369 with food science and technology (FST) counterparts. This could indicate a possible resistance of FE
370 professionals to change, evolving business requirements, and innovation. It could also indicate FE
371 possible comfortable with the status quo, as also depicted by their high values of meeting expectations
372 of current curricula. This is quite alarming as adapting curricula to diverse innovation is essential for
373 the FE field's evolution amid rapid scientific and technological advancements.

374 Embracing innovative education such as hybrid teaching, project-oriented learning, interdisciplinary
375 collaboration, nutrition integration and fostering proactive partnerships and internships is imperative
376 to meet future professional challenges and learning opportunities. Adaptability and employability
377 should be also considered. Findings underscore the importance of tailoring future curricula to regional
378 needs and differences among FST&E stakeholders.

379 **Appendix**

380 *Interview protocol* - The following paragraph was used in the introduction to the survey: Dear
381 Colleague/student, this questionnaire is part of a study aiming to: 1. Assess current Food Science &
382 Technology and Food Engineering (FST&E) professional activities and related education programs; 2.
383 identifying possible challenges and opportunities; 3. Recommending (if needed) some future curricula
384 improvements. If possible, kindly distribute the link of the questionnaire to your students and/or
385 colleagues. The responses are completely anonymous and we deeply appreciate your cooperation and
386 precious time.

387

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499 Author Contributions

500 ISS, CLMS, and EC conceived and developed the questionnaire. EC Data Curation. EC and ISS performed
501 the validation and formal statistical analysis. ISS and EC conducted the investigation and wrote the

502 manuscript. CLMS provided expertise, feedback, and final manuscript revision - supervision and project
503 administration by ISS.

504

505 **Conflicts of Interest**

506 All authors declare no conflict of interest. EC and ISS declare no financial or non-financial competing
507 interests.

508

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515

516 **Declaration of generative AI and AI-assisted technologies in the writing process**

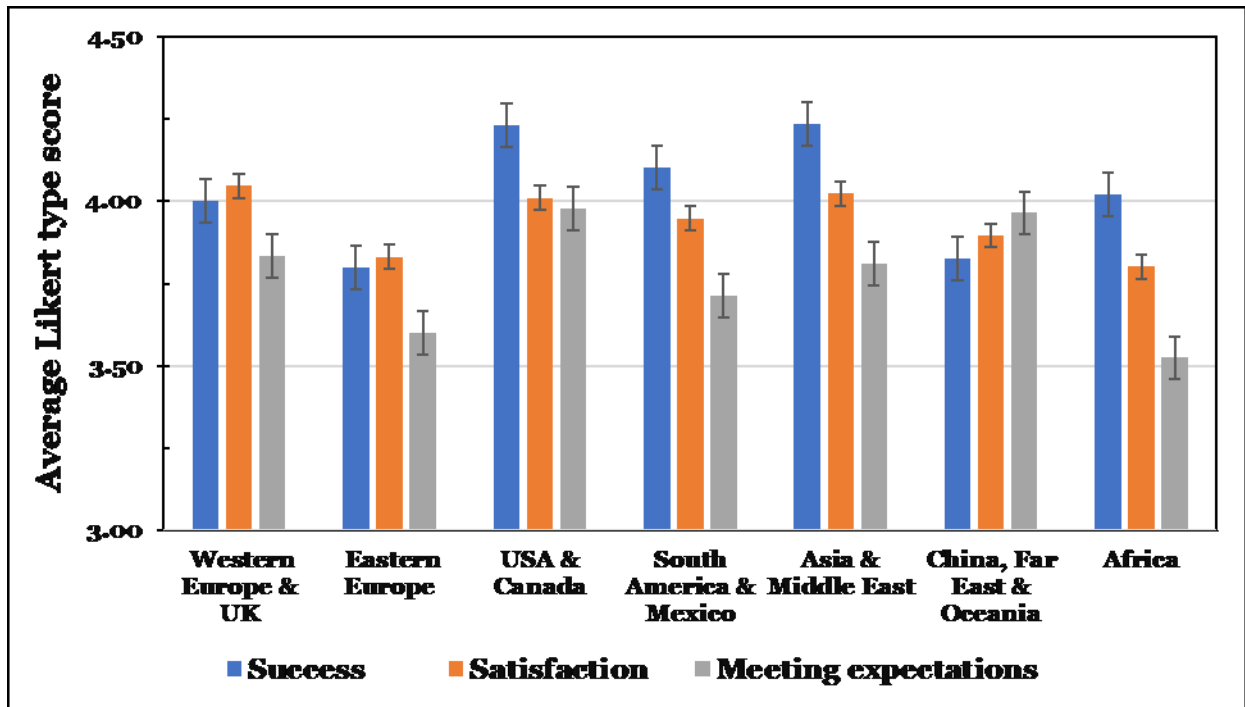
517 During the preparation of this work the authors used OpenAi.com Chapt4CPT solely for improving the
518 readability and language of the manuscript, the output was thoroughly reviewed and the content was
519 edited by the authors as needed and they take full responsibility for the content.

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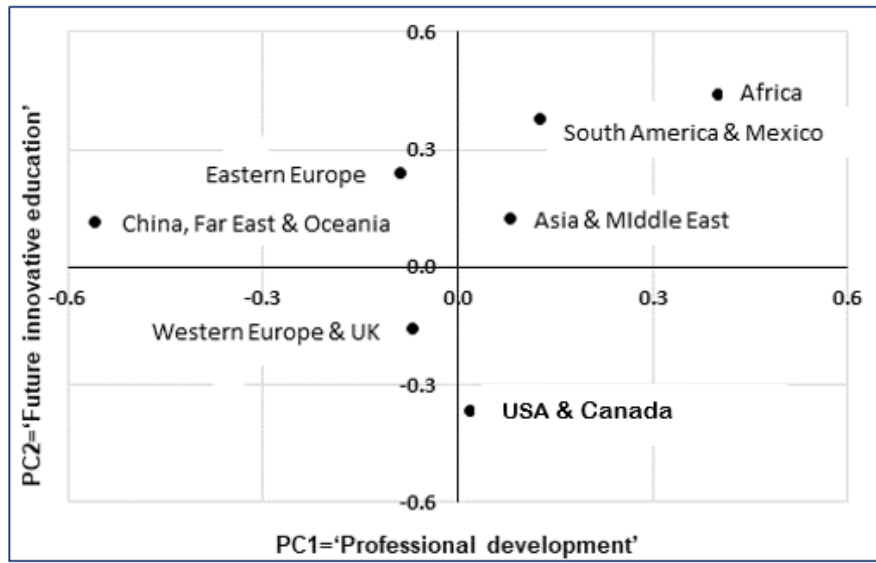
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Figure 1: Effect of education region on 'Success', 'Satisfaction', and 'Meeting expectations'

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Figure 2: PCA analysis map

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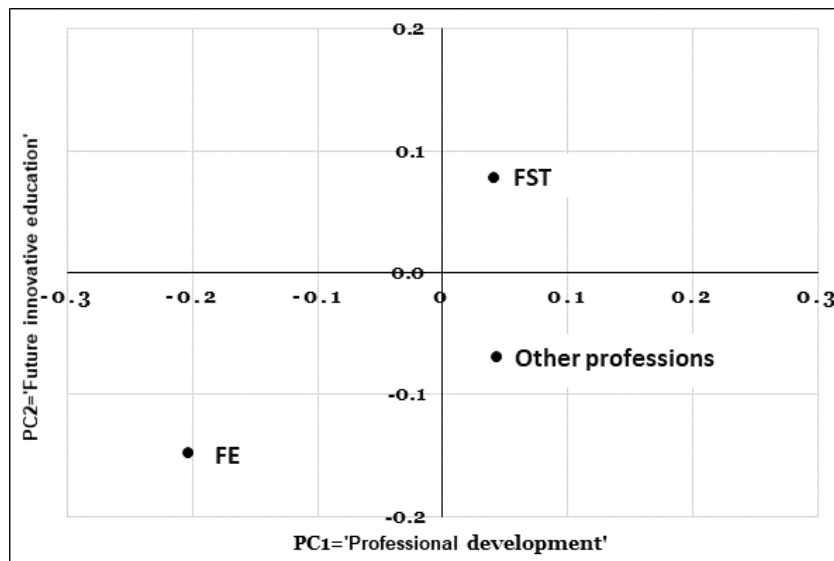
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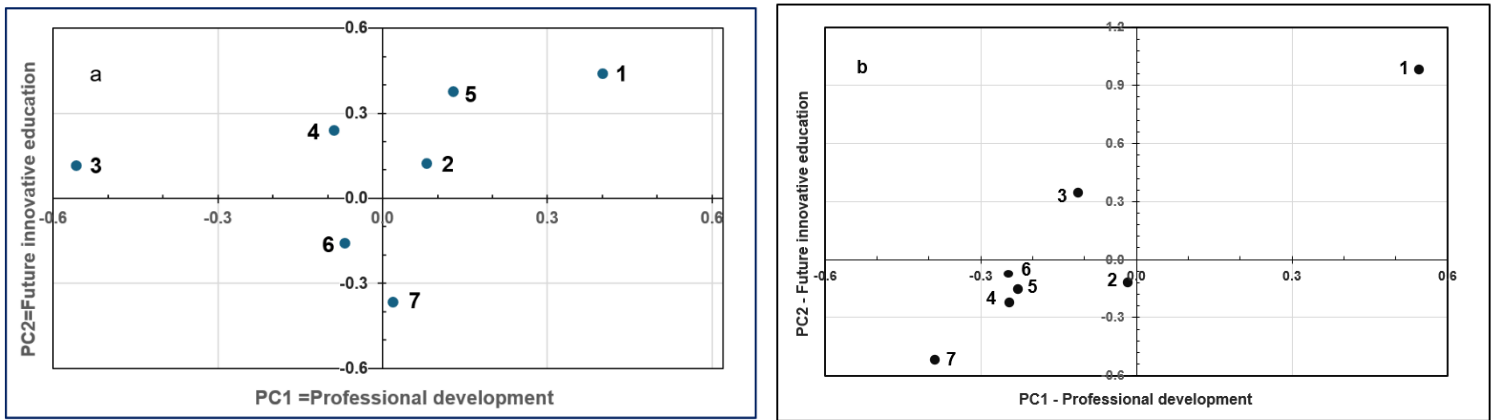
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Figure 3: PCA analysis map of FST, FE and other professions

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549 Figure 4: PCA analysis map of FST (a) and FE (b) by education region: 1. Africa; 2 Asia & Middle East; 3.
550 China, Far East & Oceania; 4. Eastern Europe; 5. South America & Mexico; 6. Western Europe & UK;
551 and 7. USA & Canada

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Table 1: Respondents' characteristics

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	Frequency	%
Respondents (panel)	688	100.0
Gender		
Female	366	53.2
Male	313	45.5
Others or not willing to answer	9	1.3
Age groups (years)		
18-25	51	7.4
26-40	176	25.6
41-55	262	38.1
Above 55	199	28.9
Education site based on the geography location where the most advanced degree was attained or where students are studying		
Western Europe & UK	211	30.7
Africa	101	14.6
Eastern Europe	95	13.8
USA & Canada	90	13.1
Asia & Middle East	85	12.4
South America & Mexico	77	11.2
China, Far East & Oceania	29	4.2
Professional classifications		
Food Science & Technology (FST)	389	56.5
Food Engineering (FE)	118	17.2
Other related professions	181	26.3

587 Table 2: The importance of FST&E topics affecting the future of the professional curricula based on
 588 respondents' education segmentation (scale 1-5 Likert-type, n=688)

Topic	Western Europe & UK	Eastern Europe	USA & Canada	South America & Mexico	Asia & Middle East	China, Far East & Oceania	Africa	Average
1. Revision of the current education programs	4.08	4.27	4.12	4.38	4.18	4.00	4.38	4.20
2. Hybrid (remote and frontal) teaching	3.71	3.79	3.67	3.91	3.89	3.97	4.08	3.86
3. Apprenticeships (e.g., industrial training)	4.19	4.46	4.31	4.23	4.35	4.07	4.55	4.31
4. Enhanced integration with nutrition	3.80	4.04	3.50	4.04	4.05	4.10	4.36	3.98
5. Research project(s)	4.31	4.44	4.18	4.31	4.39	4.10	4.63	4.34
6. Soft (life) skills	3.85	3.78	3.87	3.88	4.14	3.69	4.19	3.91
7. Employability	4.11	4.16	4.18	4.06	4.16	3.79	4.50	4.14
8. Adaptability (e.g., adjusting to change in real-time, managing biases, overcoming challenges)	4.22	4.18	4.26	4.32	4.18	4.03	4.44	4.23
9. Business-related (e.g., creation, network, partnership, collaboration)	3.82	4.01	3.78	3.94	3.99	3.62	4.35	3.93
Average	4.01	4.13	3.99	4.12	4.15	3.93	4.39	

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Table 3: Loadings of the perceived importance of FST&E future topics

	Component	
	PC1	PC2
Adaptability (e.g., adjusting to change in real time, managing biases, overcome challenges)	0.757	
Employability	0.743	
Business related (e.g., creation, network, partnership, collaboration)	0.714	
Soft (life) skills	0.689	
Apprenticeships (e.g., industrial training)	0.455	
Hybrid (remote and frontal) teaching		0.743
Revision of the current education programs		0.717
Enhanced integration with nutrition		0.521
Research project(s)		0.461

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