

1 **Explaining and validating the green curriculum’s characteristics based on**
2 **the critical competencies of education for the 21st century**

3
4 **Maryam Hosseini Largani¹, Hossein Taimour², and Mahsa Saadvandi^{2*}**

5 **Abstract**

6 This study aims to explain and validate the characteristics of a green curriculum (GC) based on
7 critical competencies required for 21st-century education. A mixed-methods approach was
8 employed. In the qualitative phase, experts with experience in sustainability within Iran’s higher
9 education system were selected through snowball sampling. Data were collected via semi-
10 structured interviews and analyzed using content analysis. The identified GC characteristics were
11 then quantitatively validated using the Lawshe method. For this, 40 faculty members and doctoral
12 students in educational sciences were randomly selected to evaluate the appropriateness of these
13 characteristics on a three-level scale. The results identified 50 characteristics from interviews and
14 documents, with 48 being validated through the Lawshe method. Additionally, the study found
15 that each of the five competencies for 21st-century education (learning to know, learning to be,
16 learning to do, learning to live together, and learning to transform oneself and society) aligns with
17 several GC characteristics. Recommendations for operationalizing these competencies within a
18 GC include integrating environmental management into various academic curricula, defining
19 practical projects for students, and encouraging engagement with environmental organizations and
20 global research communities.

21 **Keywords:** Environmental challenges, sustainability, green university, green curriculum.

22 **Introduction**

23 **Green University**

24 Due to increasing concern about various environmental issues, universities are expected to
25 contribute to solving these problems by generating relevant knowledge and integrating
26 sustainability into their programs. This expectation has led to the introduction of the concept of a
27 green university (Shu et al., 2024; Khoderchah and Semaan, 2024). Although “green” is a broad

¹ Educational and Curricular Innovations Group, Institute for Research and Planning in Higher Education, Tehran, Islamic Republic of Iran.

² Department of Agricultural Extension and Education, College of Agriculture, Tarbiat Modares University (TMU), Tehran, Islamic Republic of Iran.

* Corresponding author; e-mail: m.saadvandi@modares.ac.ir

28 and complex concept encompassing environmental concerns, protection of the planet and animals,
 29 humanitarian concerns, fair trade, clean water, welfare, equality, and sustainability (Nowak, 2023),
 30 in higher education, it represents an approach proposed under the concept of sustainable
 31 development, highlighting the serious responsibility of higher education in this regard (Deriu and
 32 Gallo, 2024). The first thought that comes to mind when hearing about a green university is often
 33 a green campus. However, it refers to all human activities in the 21st century that cause the least
 34 damage to the environment (Pouramini and Bashokouh, 2024). Following the introduction of the
 35 green university concept, several assessment systems have been designed to monitor the activities
 36 of green universities worldwide (Figure 1).

<p>The Holcim Awards (Damati, 2013)</p>	<ul style="list-style-type: none"> • Progress: Innovation, and transferability • People: Ethical Standards and Social Equity • Planet: Environmental Quality and Resource Efficiency 	<ul style="list-style-type: none"> • Prosperity Economic Performance and Compatibility • Proficiency Contextual and Aesthetic Impact
<p>STARS (Atici et al., 2013)</p>	<ul style="list-style-type: none"> • Operations: Energy, water, waste, transportation, and other operational aspects. • Academics: Sustainability in curriculum and research • Innovation and Leadership: Innovative and exemplary sustainability practices 	<ul style="list-style-type: none"> • Planning and Administration: Coordination and planning, diversity and affordability, investment and finance, and wellbeing and work • Engagement: Campus engagement and public engagement in sustainability efforts
<p>Green Report System (Shi and Lai, 2013)</p>	<ul style="list-style-type: none"> • Administration • Climate change and energy • Food and recycling • Green building • Student involvement 	<ul style="list-style-type: none"> • Transportation • Endowment transparency • Investment priorities • Shareholder engagement
<p>Green Building System (Marrone et al., 2018)</p>	<ul style="list-style-type: none"> • Energy efficiency • Indoor environmental quality • Sustainable site development • Water efficiency 	<ul style="list-style-type: none"> • Materials and resources • Innovation in design • Transportation
<p>Green Metric (Marrone et al., 2018)</p>	<ul style="list-style-type: none"> • Setting and infrastructure • Energy and climate change • Waste and waste management 	<ul style="list-style-type: none"> • Water conservation • Transportation • Education and research

37

Figure 1. Green Universities Ranking systems.

38 As shown in Figure 1, among the six ranking systems defined for green universities, only two
39 systems consider education as a criterion: STARS and Green Metric. The former is specifically
40 designed for American and Canadian universities and is not a global ranking system (Atici et al.,
41 2013). The latter system emphasizes the physical environment, with education presented implicitly
42 alongside research. Chankrajang and Muttarak (2017) studied the contribution of education to pro-
43 environmental behavior and confirmed that education significantly increases the probability of
44 taking knowledge-based environmentally-friendly actions. Kountouris and Remoundou (2023)
45 also found that education improves some types of environmentally friendly activities, such as
46 waste recycling. Therefore, educational aspects are underestimated in green university assessments
47 and need more attention.

48 Despite the increasing emphasis on sustainability in higher education, current green university
49 assessment systems inadequately address the educational aspects of sustainability. Most systems
50 focus primarily on the physical environment, neglecting the critical role of education in fostering
51 pro-environmental behaviors and competencies. This oversight limits the effectiveness of green
52 universities in promoting comprehensive sustainability education.

53 Addressing this gap is crucial because education is a powerful tool for instilling sustainable
54 practices and mindsets in future generations. Without a strong educational component, green
55 universities cannot fully achieve their potential in driving societal change towards sustainability.
56 This research aims to bridge this gap by validating the characteristics of a green curriculum based
57 on the critical competencies of education for the 21st century.

58 This study provides a detailed analysis of the educational dimensions of green universities,
59 proposing a framework for integrating sustainability into higher education curricula. By focusing
60 on the critical competencies identified by UNESCO, this research offers practical guidelines for
61 developing green curricula that equip students with the knowledge, skills, attitudes, and values
62 necessary for sustainable living.

63 64 **Green Curriculum**

65 According to the Illinois Central College Curriculum Committee in the United States, a green
66 curriculum is related to sustainability and equips learners with the knowledge and skills to identify,
67 analyze, and solve problems in various social, economic, and environmental domains (ICC, 2023).
68 The green curriculum aims to integrate sustainability into the teaching process so that learners

69 obtain sufficient knowledge and skills to become “Sustainability Minded Citizens.” The primary
70 purpose of sustainable thinking is to empower individuals to comprehend the complex issues of
71 sustainability and the challenges facing human society at local and global levels, enabling them to
72 seek logical solutions to these problems (Taqipour et al., 2016; Singer-Brodowski et al., 2018).
73 Previous studies related to the green curriculum confirm that this type of curriculum focuses on
74 environmental crises and often aims to empower people to solve these crises.

75 According to UNESCO’s Greening Curriculum Guidance, integrating climate mitigation and
76 adaptation into teaching and learning is essential for fostering a holistic, scientifically accurate,
77 and justice-driven approach to climate change education (UNESCO, 2024). Hays and Reinders
78 (2020) discussed that the concept of sustainable learning and education (SLE) emphasizes creating
79 curricula that instill skills and dispositions necessary for thriving in challenging circumstances.
80 The integration of sustainability in the green curriculum is crucial for developing an
81 environmentally conscious mind-set in students. Gabrys et al. (2020) emphasize problem-solving
82 in a coached apprenticeship system, which can be applied to green education through real-world
83 environmental challenges. Avvisati and Borgonovi (2020) show that problem-solving in
84 mathematics enhances analytical skills vital for sustainability. Rebello et al. (2017) highlight the
85 need for an interdisciplinary approach to address complex scientific problems, stressing the
86 importance of a green curriculum that incorporates sustainability across various subjects.
87 Furthermore, Karami et al. (2020) examined the green curriculum in Iranian universities,
88 emphasizing the water crisis, climate change, and knowledge supply sources. They suggested
89 developing a green curriculum aligned with climate change management in Iran, including creating
90 a department for curriculum development and revision in all universities of the Ministry of
91 Science, Research and Technology according to the country’s water conditions, and dedicating
92 part of the lessons to climate change management at different education levels. Another study
93 considered the green curriculum as a tool for sustainable learning, indicating that it should be used
94 to allow people to solve their problems in communities through radical problem-solving initiatives
95 and ideas. Transformative solutions, which are holistic, not only are profitable but also save people
96 and the planet (Louw, 2013). Haigh (2005) indicated that universities should equip all their
97 students with “environmental literacy,” and sustainability must be the central point of curricula
98 and all practices of any university worldwide. Greening the curriculum is considered a plan to
99 ensure students’ ability to face the challenges of the 21st century, such as global warming and

100 climate change, social inequalities, unsustainable lifestyles, and the urgent need to move to an
101 economy based on renewable energy (Greenheart Education, 2019). Accordingly, the green
102 curriculum also covers the critical competencies of education for the 21st century. Competency in
103 this context refers to a combination of knowledge, skills, attitudes, and values that students need
104 to effectively navigate and succeed in various aspects of life, including personal, academic, and
105 professional domains (Koeppen et al., 2008). These competencies, which correspond to basic skills
106 and required characteristics for sustainable activities, are identified by UNESCO and presented in
107 Delors's report (1996) as follows:

108 **Learning to know:** Obtaining the instruments of understanding or learning how to learn, which
109 can be considered a foundation for lifelong learning.

110 **Learning to do:** Applying learned knowledge in daily life to improve the ability to be creative
111 and responsible toward the surrounding environment.

112 **Learning to be:** Obtaining universally shared values, developing one's personality, self-identity,
113 and self-knowledge, becoming immersed in one's culture and wisdom, and being empowered to
114 learn about oneself and become more fully human.

115 **Learning to live together:** Education for international and intercultural understanding is essential
116 for fostering the social dimension of human development. It serves as the foundation for cohesion
117 and harmony, conflict avoidance, non-violence, and peaceful coexistence. Recognizing that
118 difference and diversity are opportunities rather than dangers, this competency emphasizes the
119 value of diversity as a resource for the common good. It promotes the ability to tolerate, respect,
120 welcome, and celebrate differences in people, their histories, traditions, beliefs, values, and
121 cultures, using this diversity to enrich our lives and classrooms.

122 **Learning to transform oneself and society:** This competency focuses on working towards a
123 gender-neutral, non-discriminatory society and acting to achieve social solidarity and international
124 understanding. Above all, it emphasizes living sustainably (Shaeffer, 2007).

125 Given the above explanations, it is clear that the green university movement is a crucial approach
126 to addressing and mitigating environmental concerns in the contemporary era. However, despite
127 the critical role of education in this journey, current ranking systems for green universities have
128 not sufficiently considered educational aspects. Due to the significance of green education, it aligns
129 well with the critical competencies of education for the 21st century, as introduced by UNESCO.
130 Therefore, this study aims to design and validate a green curriculum model based on these critical

131 competencies. To achieve this aim, we have formulated two research questions:

132 What are the characteristics of a green curriculum?

133 How can we categorize the characteristics of a green curriculum based on the competencies of
134 education for the 21st century?

135

136 **Methods**

137 **Research Design**

138 This study employed a mixed-methods approach, combining qualitative and quantitative
139 paradigms to explore and validate the characteristics of a green curriculum based on the critical
140 competencies of education for the 21st century. The exploratory nature of the initial phase justified
141 the use of qualitative methods, allowing for an in-depth understanding of the research topic. The
142 subsequent phase utilized quantitative methods to validate the content of the green curriculum
143 characteristics.

144

145 **Qualitative Phase**

146 In the first phase, we conducted semi-structured interviews with 12 experts in education and
147 sustainability. These experts were selected using snowball sampling, ensuring a diverse and
148 knowledgeable participant pool. The interview questions focused on identifying the characteristics
149 and components of a green curriculum. Data collection continued until theoretical saturation was
150 reached, indicating comprehensive coverage of the topic. Additionally, we conducted a
151 documentary analysis of 14 published articles and a dissertation related to green curriculum, using
152 content analysis techniques. The accuracy of this procedure was verified through constant
153 comparison (Schilling, 2006). Thus, 10% of all selected documents were examined by two
154 researchers at the same time using research tools (including index cards proposed by Padang et al.
155 (2018) to systematically gather and organize data, ensuring a structured and efficient approach to
156 documentary analysis) and then the results were compared. Since more than 90% of the results
157 were similar, the accuracy of the research tool was confirmed. To analyse the data, content analysis
158 according to Borg and Gall (1984) was used. Accordingly, the texts of both the interviews and
159 documents were carefully studied, and firstly, in the open coding, all statements illustrating
160 characteristics of the green curriculum were extracted. In the next step, categorization was done
161 thorough the axial coding. Considering that the basis of this research was the key competencies of
162 education for the 21st century, therefore, central coding was done on this basis.

163

164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194

Quantitative Phase

In the second phase, we employed the Lawshé method to assess the content validity of the green curriculum characteristics. A questionnaire containing the identified characteristics was distributed to a panel of 40 experts, who evaluated each item as “necessary,” “useful but unnecessary,” or “unnecessary.” The Content Validity Ratio (CVR) was calculated for each item using the following formula:

$$CVR = \frac{ne - N/2}{N/2}$$

Where (ne) is the number of panellists indicating “necessary” and (N) is the total number of panellists. The minimum acceptable value of CVR for a panel of 40 members is 0.29 (Paykari et al., 2018). Items with lower values were omitted.

Additionally, the Content Validity Index (CVI) was calculated to assess the simplicity, clarity, and relevance of the characteristics. The CVI was determined using the following formula:

$$CVI = \frac{\text{The number of experts giving rate 3 or 4}}{\text{Total number of experts}}$$

Panel members rated each item on a 4-point scale, and the minimum acceptable CVI value for the remaining items in the questionnaire is 0.79 (Munro, 2005).

Results

Descriptive Findings

To determine the characteristics of the green curriculum, we conducted interviews with 12 experts in the field of curriculum planning. The total duration of these interviews was 477 minutes, averaging 39.75 minutes per interview. To supplement and enrich the data obtained from the interviews, we also reviewed a set of related documents. These documents included 15 research studies published in national and international databases, predominantly articles in English, along with a doctoral dissertation and a scientific research article in Farsi. Detailed bibliographic information on these sources is provided in Appendix 2.

195
 196 **Inferential Findings**
 197 The content analysis of the interviews resulted in the identification of 38 characteristics of the
 198 green curriculum. Table 1 below summarizes the key concepts extracted from the interviews.

199 **Table 1.** Concepts extracted from interviews regarding the green curriculum characteristics.

Concepts extracted from interviews	Number of citations
Emphasis on creating a positive attitude toward environmental issues among students	6
Increasing students' awareness of the current environmental issues in the world	5
Teaching a critical attitude towards behaviors and activities that affect the environment	5
Benefiting from educators who believe in sustainability	5
Considering social responsibility in the content of the green curriculum	5
Considering the principles of sustainability and environmental protection in the curriculum evaluation stage	5
Providing the opportunity for students to respond to environmental challenges in nature	5
Developing a curriculum based on the ecological needs of the society	5
Using teaching-learning approaches based on interaction in order to promote the spirit of empathy in solving environmental hazards among learners	4
Emphasis on problem-oriented education based on solving environmental problems	4
Teaching the operational principles of paying attention to sustainability in any specialized work related to people's profession	3
Improving people's creativity in solving environmental challenges	3
Emphasizing the necessity of environmental protection in the green curriculum	3
Emphasis on minimizing environmental risks	3
Emphasis on systemic thinking and attention to the relationship between environmental components	3
Paying attention to the education of citizenship or global citizen in the content of the green curriculum	3
Considering the principles of sustainability and environmental protection in the curriculum design phase	3
Introducing knowledge resources related to sustainability to learners as auxiliary resources	3
Introducing knowledge resources related to sustainability to learners as main resources	3
Introducing knowledge resources related to sustainability to learners as non-curriculum resources	3
Enabling the students to consider the consequences of personal behaviors and paying attention to the direct effects of these behaviors	2
Enabling the students to consider the consequences of personal behaviors and paying attention to the indirect effects of these behaviors	2
Integrating different aspects of sustainable development in the content of the green curriculum	2
Teaching the sustainability skills to students (students' ability to combine the principles of sustainability with all aspects of life)	2
Considering the issue of social justice (rights of the next generation) in the content of the green curriculum	2
Considering the issue of environmental culture in the content of the green curriculum	2
Encouraging students to learn lifelong environmental issues	2
Focus on changing students' behavior to achieve sustainability in society	2
Using educational resources related to the environment	1
Informing students about political relations effective on environmental risk management	1
Creating an opportunity for students to exchange their experiences related to environmental management	1
Considering topics related to personal adaptation in the content of the green curriculum	1
Emphasizing public interest repeatedly in the curriculum	1
Encouraging students to pursue environmentally friendly trans-sectoral activity	1
Encouraging students to consider sustainability in economic activities	1
Considering the principles of sustainability and environmental protection in the curriculum implementation phase	1
Using environmental symbols and signs in the learning environment	1
Encouraging students to consider future consequences of various activities	1

200
201 In the content analysis of the documents related to the green curriculum, 23 characteristics of
202 the green curriculum were extracted. Among these characteristics, there are 11 similar items to
203 those extracted from the interviews, marked with (*) in Table (2).

204
205 **Table 2.** Concepts extracted from documents regarding the green curriculum characteristics.

Concepts extracted from the reviewed documents	Number of citations
Using environmental symbols and signs in the learning environment*	8
Providing environmental knowledge originated from high-quality research	4
Increasing students' awareness of the current environmental issues in the world*	4
Empowering students for addressing real environmental issues or concerns	4
Emphasis on systemic thinking and attention to the relationship between environmental components*	4
Benefiting from educators who believe in sustainability*	3
Teaching the operational principles of paying attention to sustainability in any specialized work related to people's profession*	2
Developing practical guidelines for environmental education	2
Creating a positive attitude toward environmental protection among students	2
Encouraging students to learn lifelong environmental issues*	2
Integrating green concepts into the curriculum	2
Explaining the philosophy and basic concepts of the green curriculum	2
Considering the principles of sustainability and environmental protection in the curriculum evaluation stage*	2
Considering optional courses for students who are interested in gaining expertise in environmental protection	2
Equipping students with the knowledge and skills to monitor environmental problems and concerns	2
Emphasizing the necessity of environmental protection in the green curriculum*	1
Encouraging students to consider sustainability in economic activities*	1
Defining homework related to the environment to encourage students' short-term achievements	1
Considering the principles of sustainability and environmental protection in the curriculum implementation phase*	1
Explaining sustainability in various industrial processes	1
Explaining sustainability in various social processes	1
Providing the opportunity for students to respond to environmental challenges in nature*	1
Introducing and teaching the use of green technologies	1

206 * Common concepts in both interviews and documents

207 **More explanations about the characteristics in Table 1 and Table 2 is provided in the Appendix (2).

208
209 In this research, the key competencies of education for the 21st century (Shaeffer, 2007) were used
210 as a theoretical framework. Accordingly, axial coding was performed to check the alignment of all
211 extracted characteristics with these competencies (see Table 3). Subsequently, the values of
212 Content Relevance Value (CRV) and Content Validity Index (CVI) were calculated. In the
213 category of "learning to know," the CRV values for two items were less than 0.29. However, all
214 items had an acceptable CVI value.

215

216
217 **Table 3.** Adjusting green curriculum characteristics with key competencies of education for the
218 21st century and the amount of CRV and CVI.

Key competencies of education for the 21st century	Green curriculum characteristics	CRV	CVI
Learning to know	Providing environmental knowledge originated from high-quality research	.900	1
	Using educational resources related to the environment	.944	.875
	Informing students about political relations effective on environmental risk management	.589	.923
	Increasing students' awareness of the current environmental issues in the world	.900	.897
	Integrating green concepts into the curriculum	.850	.925
	Explaining the philosophy and basic concepts of the green curriculum	.487	.900
	Benefiting from educators who believe in sustainability	.589	.925
	Introducing knowledge resources related to sustainability to learners as auxiliary resources	.550	.897
	Introducing knowledge resources related to sustainability to learners as main resources	.650	.950
	Introducing knowledge resources related to sustainability to learners as non-curriculum resources	.250*	.875
	Considering the principles of sustainability and environmental protection in the curriculum implementation phase	.350	.890
	Considering optional courses for students who are interested in gaining expertise in environmental protection	.800	.850
	Considering the principles of sustainability and environmental protection in the curriculum design phase	.250*	.875
	Equipping students with the knowledge and skills to monitor environmental problems and concerns	.800	.925
	Integrating different aspects of sustainable development in the content of the green curriculum	.846	.900
	Considering the principles of sustainability and environmental protection in the curriculum evaluation stage	.500	.875
	Learning to do	Developing practical guidelines for environmental education	.894
Teaching the operational principles of paying attention to sustainability in any specialized work related to people's profession		.857	.951
Improving people's creativity in solving environmental challenges		.785	.961
Using environmental symbols and signs in the learning environment		.700	.950
Encouraging students to learn lifelong environmental issues		.743	.925
Emphasis on problem-oriented education based on solving environmental problems		.735	.950
Defining homework related to the environment to encourage students' short-term achievements		.726	.916
Providing the opportunity for students to respond to environmental challenges in nature		.722	.980
Introducing and teaching the use of green technologies		.719	.865
Focus on changing students' behavior to achieve sustainability in society		.716	.895
Explaining sustainability in various industrial processes		.700	.975
Explaining sustainability in various social processes		.641	.925
Empowering students for addressing real environmental issues or concerns		.600	.975
Emphasizing the necessity of environmental protection in the green curriculum	.850	.948	

Key competencies of education for the 21st century	Green curriculum characteristics	CRV	CVI
Learning to be	Encouraging students to consider sustainability in economic activities	.478	.923
	Teaching a critical attitude towards behaviors and activities that affect the environment	.692	.975
	Enabling the students to consider the consequences of personal behaviors and paying attention to the direct effects of these behaviors	.789	.925
	Enabling the students to consider the consequences of personal behaviors and paying attention to the indirect effects of these behaviors	.700	.925
	Teaching the sustainability skills to students (students' ability to combine the principles of sustainability with all aspects of life)	.750	.950
	Emphasis on creating a positive attitude toward environmental issues among students	.800	.948
	Using teaching-learning approaches based on interaction in order to promote the spirit of empathy in solving environmental hazards among learners	.850	.948
	Creating an opportunity for students to exchange their experiences related to environmental management	.700	.973
	Creating a positive attitude toward environmental protection among students	.750	.925
	Considering social responsibility in the content of the green curriculum	.600	.947
Learning to live together	Emphasis on minimizing environmental risks	.794	.925
	Emphasis on systemic thinking and attention to the relationship between environmental components	.641	.950
	Emphasizing public interest repeatedly in the curriculum	.550	1
	Considering topics related to personal adaptation in the content of the green curriculum	.692	.925
	Considering the issue of social justice (rights of the next generation) in the content of the green curriculum	.692	1
	Considering the issue of environmental culture in the content of the green curriculum	.794	.950
Learning to transform oneself and society	Encouraging students to pursue environmentally friendly trans-sectoral activity	.600	.950
	Paying attention to the education of citizenship or global citizen in the content of the green curriculum	.743	1
	Developing a curriculum based on the ecological needs of the society	.743	.923
	Encouraging students to consider future consequences of various activities	.794	.973

219

220 To summarize the key findings, it can be mention that this study systematically identified 50
 221 characteristics of a green curriculum through comprehensive expert interviews and an extensive
 222 review of relevant literature. These characteristics were meticulously aligned with the key
 223 competencies essential for 21st-century education. The validity of each characteristic was
 224 rigorously assessed using the Content Validity Ratio (CVR) and Content Validity Index (CVI) as
 225 per the Lawshe method. These findings provide a robust framework for the development of a green
 226 curriculum that is both contemporary and educationally sound.

227

228 Discussion and Conclusions

229 The growing importance of sustainability necessitates that higher education systems integrate
230 environmental principles into their curricula. Traditionally, universities have focused on
231 sustainability in the physical environment, but the influence of higher education on human
232 resources is equally significant. In today's world, the role of human resources in driving societal
233 progress cannot be underestimated. Therefore, competencies such as learning to know, learning to
234 do, learning to live together, learning to be, and learning to transform oneself and society are
235 essential (Shaeffer, 2007). This study classifies the characteristics of a green curriculum based on
236 these dimensions.

237

238 Learning to Know

239 This competency involves expanding learners' knowledge to create a well-informed, proactive,
240 and engaged population capable of addressing global environmental challenges. For example,
241 empowering learners to identify environmental problems is a key characteristic of the green
242 curriculum, as confirmed by previous research (Pe'er et al., 2007; Otto & Pensini, 2017). This
243 competency includes providing environmental knowledge, encouraging lifelong learning, and
244 introducing reliable sources for acquiring knowledge. Supporting researchers in environmental
245 and curriculum development fields and integrating sustainability content across all academic
246 disciplines are recommended. Additionally, the green curriculum should empower learners to
247 identify, recall, explain, discuss, and evaluate environmental issues, concerns, values, and
248 problems at different levels from local to global society.

249

250 Learning to Do

251 This competency emphasizes the application of knowledge in everyday life, leading to the
252 consolidation of learning and societal benefits from trained human resources. In green learning,
253 which empowers individuals to fulfil their citizenship roles, problem-oriented education is crucial.
254 Teaching through problem-solving methods, as highlighted by various researchers (Gabrys et al.,
255 2020; Avvisati & Borgonovi, 2020; Rebello et al., 2017), involves students in environmental issues
256 and encourages them to find solutions. This approach should be integrated into curriculum design,
257 with practical assignments and projects that have tangible environmental management outcomes.

258 For instance, arranging scientific short trips to areas impacted by human activities can enhance
259 practical learning.

260

261 **Learning to Live Together**

262 This competency prepares individuals for a better life by empowering them to make informed
263 decisions and understand the consequences of their behaviors on the environment. Critical thinking
264 and the ability to evaluate personal behaviors are essential. Educational systems should provide
265 opportunities for learners to apply sustainability principles in practical projects and share their
266 achievements with others. Emphasizing responsibility, empathy, systemic thinking, and
267 minimizing environmental risks are key characteristics of the green curriculum. For example,
268 teaching the consequences of personal behaviours and fostering a critical view towards activities
269 affecting the environment are crucial.

270

271 **Learning to Transform Oneself and Society**

272 This highest level of learning involves seeking positive changes in oneself and society. In the
273 context of environmental and sustainability issues, this means encouraging learners to engage in
274 environmentally friendly extracurricular activities and collaborate with various societal sectors.
275 The green curriculum should prepare students for interdisciplinary and trans-organizational work,
276 fostering self-transformation and societal improvement. For instance, training students to work
277 across sectors and value interdisciplinary thinking can significantly contribute to societal
278 transformation.

279 The main limitation of our study was the reliance on the opinions of Iranian experts due to
280 constraints in time, budget, and access to international researchers. Despite these constraints, we
281 ensured the comprehensiveness and validity of our findings by reviewing publications from global
282 experts. This approach enriched our study with diverse perspectives, enhancing its overall quality
283 and relevance.

284

285 **Future Research Directions:**

286 Future research should focus on expanding international collaboration and conducting
287 longitudinal studies to track the long-term impact of green curriculum initiatives. Interdisciplinary
288 approaches and technology integration can enhance curriculum delivery, while policy impact

289 analysis and cultural context studies can identify best practices. Exploring practical applications
290 of green curriculum principles, methods to increase student engagement, and new assessment
291 methods are also crucial. Additionally, involving the community in green curriculum initiatives
292 can provide valuable insights for curriculum developers. These suggestions aim to build on current
293 findings and further promote sustainability and environmental awareness.

294

295 References

296 Atici, K. B., Yasayacak, G., Yildiz, Y., & Ulucan, A. (2021). Green University and academic
297 performance: An empirical study on UI GreenMetric and World University Rankings.
298 *Journal of Cleaner Production*, 291, 125289. <https://doi.org/10.1016/j.jclepro.2020.125289>

299 Avvisati, F., & Borgonovi, F. (2020). Learning mathematics problem solving through test
300 practice: A randomized field experiment on a global scale. *Educational Psychology Review*,
301 32(3), 791-814. <https://doi.org/10.1007/s10648-020-09520-6>

302 Borg, W. R., & Gall, M. D. (1984). Educational research: An introduction. *British Journal of*
303 *Educational Studies*, 32(3). <https://philpapers.org/rec/BORERA-2>

304 Bussiek, P. B. V., De Poli, C., & Bevan, G. (2018). A scoping review protocol to map the
305 evidence on interventions to prevent overweight and obesity in children. *BMJ open*, 8(2),
306 e019311. <https://doi.org/10.1136/bmjopen-2017-019311>

307 Chankrajang, T., & Muttarak, R. (2017). Green returns to education: Does schooling contribute
308 to pro-environmental behaviours? Evidence from Thailand. *Ecological Economics*, 131,
309 434-448. <https://www.sciencedirect.com/science/article/abs/pii/S0921800915304857>

310 Damati, S. (2013). Principles in green architecture: an inquiry into the evaluation criteria of green
311 awards (Master's thesis, Middle East Technical
312 University). <https://open.metu.edu.tr/handle/11511/22451>

313 Delors, J. (1996). Learning: The treasure within. Report to UNESCO of the International
314 Commission on Education for the Twenty-first Century. UNESCO.
315 https://www.seameo.org/img/Programmes_Protocols/Competition/SEAMEOJapanESD_Award/2013_SEAMEOJapanESD_Award/pub/delors_e.pdf
316

317 Deriu, F., & Gallo, R. (2024). Sustainable green educational paths in the Italian higher education
318 institutions: A text mining approach. *Sustainability*, 16(13), 5497.
319 <https://www.mdpi.com/2071-1050/16/13/5497>

320 Gabrys, G., Arlene, W., & Lesgold, A. (2020). Learning by problem solving in a coached
321 apprenticeship system. In *Cognitive science foundations of instruction* (pp. 119-148).
322 Routledge. <https://doi.org/10.4324/9781315044712-5>

- 323 Greenheart Education. (2019). Greening the curriculum: Ensuring students' ability to face 21st-
324 century challenges. Greenheart Education. [https://www.greenhearted.org/greening-the-
curriculum.html](https://www.greenhearted.org/greening-the-
325 curriculum.html)
- 326 Haigh, M. (2005). Greening the University Curriculum: Appraising an International Movement.
327 Journal of Geography in Higher Education, 29(1), 31–48.
328 <https://doi.org/10.1080/03098260500030355>
- 329 Hays, J., & Reinders, H. (2020). Sustainable learning and education: A curriculum for the future.
330 International Review of Education, 66(1), 29-52. [https://doi.org/10.1007/s11159-020-
09820-7](https://doi.org/10.1007/s11159-020-
331 09820-7)
- 332 Illinois Central College. (2023). Climate Works Pre-apprenticeship Program. Retrieved from
333 <https://icc.edu/programs/climate-works/>
- 334 Karami, Sh., Fathi Vajargah, K., Khosravi Babadi, A.A., and Farajzadeh, M. (2020). Green
335 Curriculum in the Higher Education of Iran: Water Crisis, Climate Change, Sources of
336 Knowledge. Quarterly Journal of Environmental Education and Sustainable Development, 9
337 (1), 81-94. [In Persian].
338 https://ee.journals.pnu.ac.ir/article_7228_e5769bb211b83e80be6080a454f00707.pdf
- 339 Khoderchah, E., & Semaan, N. M. (2024). The Green University Campus Diagnosis Model.
340 Process Integration and Optimization for Sustainability, 8, 1295-1307.
341 <https://link.springer.com/article/10.1007/s41660-024-00429-z>
- 342 Koeppen, K., Hartig, J., Klieme, E., & Leutner, D. (2008). Current issues in competence
343 modelling and assessment. Zeitschrift für Psychologie/Journal of Psychology, 216(2), 61-
344 73. <https://doi.org/10.1027/0044-3409.216.2.61>
- 345 Kountouris, Y., & Remoundou, K. (2023). Does higher education affect pro-environmental
346 behaviour? Evidence from household waste recycling in Greece. Environmental Research
347 Letters, 18(8), 084017. <https://doi.org/10.1088/1748-9326/ace19a>
- 348 Lawshe, C. H. (1975). A Quantitative Approach to Content Validity. Personnel
349 psychology/Berrett-Koehler Publishers. [https://doi.org/10.1111/j.1744-
6570.1975.tb01393.x](https://doi.org/10.1111/j.1744-
350 6570.1975.tb01393.x)
- 351 Louw, W. P. (2013). Green curriculum: Sustainable learning in higher education. The
352 International Review of Research in Open and Distributed Learning, 14(1), 1-15.
353 <https://doi.org/10.19173/irrodl.v14i1.1310>
- 354 Munro, B. H. (2005). Statistical methods for health care research (Vol. 1). lippincott williams &
355 wilkins.
- 356 Nowak, P. M. (2023). What does it mean that “something is green”? The fundamentals of a
357 Unified Greenness Theory. Green Chemistry, 25(12), 4625-4640.
358 <https://doi.org/10.1039/D3GC00800B>

- 359 Orsini, F., & Marrone, P. (2019). Approaches for a low-carbon production of building materials:
360 A review. *Journal of Cleaner Production*, 241, 118380.
361 <https://doi.org/10.1016/j.jclepro.2019.118380>
- 362 Otto, S., & Pensini, P. (2017). Nature-based environmental education of children: Environmental
363 knowledge and connectedness to nature, together, are related to ecological behaviour. *Global*
364 *environmental change*, 47, 88-94. <https://doi.org/10.1016/j.gloenvcha.2017.09.009>
- 365 Padang, M. N. B., Angin, R. B. P., & Saragi, D. (2018). The effect of index card match method
366 and learning motivation toward student's learning outcomes in elementary school. *Journal*
367 *of Research & Method in Education*, 8(1), 69-78.
- 368 Paykari A, Mazloumi A, Halvani GH., Ghaneh S, and Mashayekhi M. (2018). Validation and
369 reliability study of a ventilator usability assessment tool. *Occupational Medicine. Quarterly*
370 *Journal*. 10(3), 1-12. <https://doi.org/10.18502/tkj.v10i3.230>
- 371 Pe'er, S., Goldman, D., & Yavetz, B. (2007). Environmental literacy in teacher training:
372 Attitudes, knowledge, and environmental behavior of beginning students. *The journal of*
373 *environmental education*, 39(1), 45-59. <https://doi.org/10.3200/JOEE.39.1.45-59>
- 374 Pouramini, Z., & Bashokouh, M. (2024). Green University component modelling for higher
375 education (Case study: Mohaghegh Ardabil University). *Journal of Natural Environment*,
376 76(4), 715-729. https://jne.ut.ac.ir/article_93006.html?lang=en
- 377 Rebello, N. S., Cui, L., Bennett, A. G., Zollman, D. A., & Ozimek, D. J. (2017). Transfer of
378 learning in problem solving in the context of mathematics and physics. In *Learning to solve*
379 *complex scientific problems* (pp. 223-246). Routledge.
- 380 Schilling, J. (2006). On the pragmatics of qualitative assessment. *European journal of*
381 *psychological assessment*, 22(1), 28-37. <https://doi.org/10.1027/1015-5759.22.1.28>
- 382 Shaeffer, S. (2007). *Education for Sustainable Development: A Framework for Reform*.
383 UNESCO Bangkok, Asia and Pacific Regional Bureau for Education. [Online] Available at:
384 <http://www.unescobkk.org/esd>.
- 385 Shi, H., & Lai, E. (2013). An alternative university sustainability rating framework with a
386 structured criteria tree. *Journal of Cleaner Production*, 61, 59-69.
387 <https://doi.org/10.1016/j.jclepro.2013.09.006>
- 388 Shu, C., Zhao, J., Yao, Q., & Zhou, K. Z. (2024). Green Innovation and Export Performance in
389 Emerging Market Firms: A Legitimacy-based View. *Management and Organization Review*,
390 20(1), 85-110.
- 391 Singer-Brodowski, M., Beecroft, R., & Parodi, O. (2018). Learning in real-world laboratories: A
392 systematic impulse for discussion. *GAIA-Ecological Perspectives for Science and Society*,
393 27(1), 23-27. <https://doi.org/10.14512/gaia.27.S1.7>

394 Taqipour, M., Abbasi, E., Naeimi, A., Ganguly, S., and Zamani, N. (2016). An investigation of
395 self-directed learning skills among the Iranian agricultural students (Case of Agricultural
396 College, Tarbiat Modares University). Journal of Agricultural Science and Technology,
397 18(1), 15-26. <http://jast.modares.ac.ir/article-23-6847-en.html>

398 UNESCO. (2024). Greening curriculum guidance: Teaching and learning for climate action.
399 Paris: UNESCO. <https://doi.org/10.54675/AOOZ1758>

400

401

402

403 **Appendix 1: The list of the reviewed references**

- 404 Aithal, P. S., & Rao, P., 2016. Green education concepts & strategies in higher education model. *International*
405 *Journal of Scientific Research and Modern Education (IJSRME) ISSN (Online)*, 2455-563.
- 406 Capdevila, I., Bruno, J., & Jofre, L., 2002. Curriculum greening and environmental research co-ordination at the
407 Technical University of Catalonia, Barcelona. *Journal of Cleaner Production*, 10(1), 25-31.
- 408 Chakraborty, A., Singh, M. P., & Roy, M., 2018. Green Curriculum Analysis in Technological
409 Education. *International Journal of Progressive Education*, 14(1), 122-129.
- 410 Cotgrave, A., & Alkhaddar, R., 2006. Greening the curricula within construction programmes. *Journal for*
411 *Education in the Built Environment*, 1(1), 3-29.
- 412 *Haigh, M., 2005. Greening the university curriculum: Appraising an international movement. *Journal of*
413 *Geography in Higher Education*, 29(1), 31-48.
- 414 Karami, Sh., Fathi Vajargah, K., Khosravi Babadi, A.A., and Farajzadeh, M, 2020. Green Curriculum in the Higher
415 Education of Iran: Water Crisis, Climate Change, Sources of Knowledge. *Quarterly Journal of*
416 *Environmental Education and Sustainable Development*, 9 (1), 81-94.
- 417 Louw, W., 2013. Green curriculum: Sustainable learning at a higher education institution. *International Review of*
418 *Research in Open and Distributed Learning*, 14(1), 1-15.
- 419 Okaka, W. T., 2016. Developing Green University Curriculum Innovations for Sustainable Education in Africa.
420 *European Conference on Social and Behavioral Sciences*.
- 421 Okaka, W. T., 2007. Promoting Green Curriculum Approach in Science, Engineering, and Technology Training
422 Programs for the Achievement of Environmental Sustainability in the African Union Author. 2nd African
423 Regional Conference of Vice-Chancellors, Provosts, and Deans of Science, Engineering and Technology.
- 424 Şahin, E., 2008. An examination of indications for a green curriculum application towards sustainability. Ph.D.
425 Dissertation; The graduate school of natural and applied sciences of Middle East technical University.
- 426 Şahin, E., Ertepinar, H., & Teksöz, G., 2009. Implications for a Green Curriculum Application toward Sustainable
427 Development. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 37(37), 123-135.
- 428 Torre, D., Procaccianti, G., Fucci, D., Lutovac, S., & Scanniello, G., 2017. On the presence of green and sustainable
429 software engineering in higher education curricula. In *2017 IEEE/ACM 1st International Workshop on*
430 *Software Engineering Curricula for Millennials (SECM)*, 54-60), IEEE.
- 431 Wemmenhove, R., & de Groot, W. T., 2001. Principles for university curriculum greening-An empirical case study
432 from Tanzania. *International Journal of Sustainability in Higher Education*.
- 433 Wu, G., 2011. A new concept of green education: the cultivation model for successful and practical talents.
434 In *International Forum of Teaching and Studies*, 7 (1), 45. American Scholars Press, Inc.
- 435 Xiong, H., Fu, D., Duan, C., Chang'E, L., Yang, X., & Wang, R., 2013. Current status of green curriculum in higher
436 education of Mainland China. *Journal of Cleaner Production*, 61, 100-105.

Appendix 2: Explanation of the Green Curriculum Characteristics

Creating a positive attitude: Encouraging students to develop a favourable view of environmental issues.
Increasing awareness: Educating students about current global environmental problems.
Teaching critical attitude: Instilling a critical perspective on behaviours impacting the environment.
Sustainability-minded educators: Utilizing teachers who prioritize sustainability.
Social responsibility: Integrating social responsibility into the green curriculum.
Sustainability in evaluation: Including sustainability principles in curriculum assessments.
Responding to challenges: Allowing students to address environmental challenges in nature.
Ecological needs-based curriculum: Designing curriculum based on societal ecological needs.
Interactive approaches: Promoting empathy through interactive teaching methods.
Problem-oriented education: Focusing on solving environmental problems through education.
Operational principles: Teaching sustainability principles relevant to professional work.
Creativity in challenges: Enhancing creativity in solving environmental issues.
Necessity of protection: Emphasizing the importance of environmental protection.
Minimizing risks: Focusing on reducing environmental risks.
Systemic thinking: Encouraging understanding of the interconnections within the environment.
Global citizenship: Including global citizenship education in the curriculum.
Sustainability in design: Considering sustainability in curriculum design.
Auxiliary resources: Introducing supplementary sustainability resources.
Main resources: Providing primary sustainability resources.
Non-curriculum resources: Offering non-curricular sustainability resources.
Direct consequences: Teaching students to consider the direct effects of their behaviours.
Indirect consequences: Teaching students to consider the indirect effects of their behaviours.
Sustainable development: Integrating sustainable development aspects into the curriculum.
Sustainability skills: Teaching students to apply sustainability principles in life.
Social justice: Addressing social justice in the curriculum.
Environmental culture: Incorporating environmental culture into the curriculum.
Lifelong learning: Encouraging lifelong learning about environmental issues.
Behaviour change: Focusing on changing behaviours to achieve societal sustainability.
Educational resources: Using environment-related educational materials.
Political relations: Informing students about political factors in environmental risk management.
Experience exchange: Creating opportunities for students to share environmental management experiences.
Personal adaptation: Including personal adaptation topics in the curriculum.
Public interest: Repeatedly emphasizing public interest in the curriculum.
Trans-sectoral activity: Encouraging environmentally friendly activities across sectors.
Economic sustainability: Promoting sustainability in economic activities.
Implementation phase: Considering sustainability in curriculum implementation.
Environmental symbols: Using environmental symbols in the learning environment.
Future consequences: Encouraging consideration of future impacts of activities.
High-quality research: Providing knowledge from high-quality environmental research.
Addressing real issues: Empowering students to tackle real environmental concerns.
Practical guidelines: Developing practical guidelines for environmental education.
Positive attitude: Creating a positive attitude toward environmental protection.
Green concepts: Integrating green concepts into the curriculum.
Philosophy and concepts: Explaining the philosophy and basic concepts of the green curriculum.
Optional courses: Offering optional courses for environmental protection expertise.
Monitoring skills: Equipping students with skills to monitor environmental issues.
Environment-related homework: Assigning environment-related homework for short-term achievements.
Industrial sustainability: Explaining sustainability in industrial processes.
Social sustainability: Explaining sustainability in social processes.
Green technologies: Introducing and teaching the use of green technologies.