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ORIGINAL ARTICLE

Design and Validation of a Civic Education Model for Sustainable Participation in Urban Solid Waste Management

Mohammadali Nejat[1], *Saeed Motahari[2], Azita Behbahani[3], Mahdieh Rezaei[4]

1. Department of Environment, Ro.C., Islamic Azad University, Roudehen, Iran
2. Department of Environment, Ro.C., Islamic Azad University, Roudehen, Iran
3. Department of Environment, Ro.C., Islamic Azad University, Roudehen, Iran
4. Associate Professor of Environmental Education, Department of Education, Payame Noor University, Tehran, Iran

Correspondence:
Saeed Motahari
Email: samotahari@iau.ac.ir

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ABSTRACT

Education is the key that leads all waste management programs, ideas, and plans to success. However, many educational initiatives do not foster long-term participation. Therefore, this study aimed to present an educational model for sustainable citizen participation in waste management. This research is exploratory and applied. The study was conducted in two phases. First, relevant literature was reviewed using MAXQDA software to identify and classify the factors and indicators of the model. In the second phase, the designed model was validated using expert opinions and SMART PLS software. The findings revealed 12 components: environmental awareness and knowledge, teaching methods, type of education, media and communications, infrastructure and practical facilities, encouragement and motivation, social support, cultural development and behavior change, policy-making and regulations, social experiences and interactions, sustainable public participation, and governmental support, along with 53 indicators. Additionally, the Kappa coefficient confirmed the reliability of the model with a value of 0.95. The quantitative results also showed that the alpha value, divergent validity, and average variance extracted for all variables were appropriate and had high factor loadings. The highest Q^2 value was for the media and communications variable, indicating its high predictive power within the model. Moreover, the t-values and p-values for all paths supported the hypotheses of the model and its structural fit.

KEYWORDS

Civic Education, Sustainable Participation, Waste Management.

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محمدعلی نجات[۱]، *سعید مطهری[۲]، آزیتا بهبهانی‌نیا[۳]، مهدیه رضائی[۴]

۱. گروه محیط‌زیست، واحد رودهن، دانشگاه آزاد اسلامی، رودهن، ایران

۲. گروه محیط‌زیست، واحد رودهن، دانشگاه آزاد اسلامی، رودهن، ایران

۳. گروه محیط‌زیست، واحد رودهن، دانشگاه آزاد اسلامی، رودهن، ایران

۴. دانشیار، رشته آموزش محیط‌زیست، گروه علوم تربیتی، دانشگاه پیام‌نور، تهران، ایران

نویسنده مسئول:
سعید مطهری
رایانامه: samotahari@iau.ac.ir

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چکیده

آموزش شاه‌کلیدی است که همه برنامه‌ها، ایده‌ها و طرح‌های مدیریت پسماند را به موفقیت می‌رساند، اما بسیاری از آموزش‌ها مشارکت طولانی‌مدت به همراه ندارد. لذا این مطالعه با هدف ارائه یک مدل آموزشی برای مشارکت پایدار شهروندان در مدیریت پسماند انجام شد. پژوهش حاضر به لحاظ هدف، اکتشافی و ازنظر ماهیت کاربردی و توسعه‌ای است که در دو مرحله انجام شده است ابتدا مطالعات مرتبط با استفاده از نرم‌افزار مکس کیودا موردبررسی قرار گرفتند، عوامل و گویه‌های مدل، شناسایی و طبقه‌بندی گردید. در بخش دوم مدل طراحی‌شده با بهره‌گیری از نظر متخصصین و نرم‌افزار smart pls مورد اعتبار یابی قرار گرفت. یافته‌های تحقیق، ۱۲ مؤلفه آگاهی و دانش محیط زیستی، روش‌های آموزش، نوع آموزش، رسانه و ارتباطات، زیرساخت‌ها، تسهیلات عملی، تشویق و انگیزه دهی، حمایت اجتماعی، فرهنگ‌سازی و تغییر رفتار، سیاست‌گذاری و قوانین، تجربه و تعاملات اجتماعی، مشارکت پایدار مردمی و حمایت‌های دولتی و ۵۳ گویه را معرفی نمود. همچنین ضریب کاپا با مقدار ۹۵/. پایایی این مدل را تائید نموده است. نتایج بخش کمی نیز نشان داد که مقدار آلفا، روایی واگرا و متوسط واریانس استخراج‌شده برای همه متغیرها، مناسب و دارای بار عاملی بالا بوده است. بیشترین میزان Q2 برای متغیر رسانه و ارتباطات بوده است که نشان‌دهنده پیش‌بینی کنندگی بالای مدل توسط این متغیر است. همچنین مقادیر ضریب t و P-Value برای تمام مسیرها، تائید کننده فرضیه‌های مدل و برازش ساختاری بوده است.

واژه‌های کلیدی

آموزش شهروندی، مشارکت پایدار، مدیریت پسماند.

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این مقاله تحت گواهی زیر منتشرشده و هر نوع استفاده غیرتجاری از آن مشروط بر استناد صحیح به مقاله و با رعایت شرایط مندرج در آدرس زیر مجاز است.
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Introduction

Household waste is recognized as the primary component of urban solid waste in many developing countries (Esmaeilizadeh et al., 2020; Jouhara et al., 2017; Speier et al., 2018), accounting for between 55 and 85 percent of the composition of urban solid waste. This situation poses significant challenges for public management, including waste treatment (Latugan et al., 2024). It highlights the critical role of resident participation in urban waste management systems (Kamaruddin et al., 2017). Sustainable waste management at the household level remains a significant challenge due to its high dependency on resident behavior (Jiang et al., 2021; Moh & Manaf, 2017; Mukama et al., 2016), becoming a central issue in many cities in developing countries (Azevedo et al., 2021; Banerjee & Sarkhel, 2019; Gundupalli et al., 2017). Waste management follows a desirable path when the communication link between citizens and waste collection and processing operators is strengthened, and the only way to enhance this connection is through extensive education and cultural development. Previous studies have shown that education has become one of the vital factors for changing resident behavior (Meng et al., 2019; Liu et al., 2019). In other words, education is the key that ensures the success of all waste management programs, ideas, and plans, provided it is conveyed correctly and from appropriate sources to learners. However, due to the remaining challenges and issues in urban waste management, existing educational programs for residents in developing countries are considered ineffective and inadequate (Moh & Manaf, 2017; Wang et al., 2018). Education cannot directly influence residents' behavior regarding waste management (Wang et al., 2018); this influence is mediated by personal factors such as awareness (Chen & Gao, 2020; Lissah et al., 2021; Pierini et al., 2021), attitudes (Lissah et al., 2021; Liu et al., 2019; Wang et al., 2018), and moral norms (Wang et al., 2018), effectively nurturing residents' willingness to participate and change their behavior (Liu et al., 2019; Meng et al., 2019; Wang et al., 2018). Educational strategies need to be improved to be more effective and impactful, reinforcing personal factors (Chen & Gao, 2020; Pierini et al., 2021; Wang et al., 2018; Zheng et al., 2020). This situation raises the question of which educational strategies and factors are most effective and impactful in creating sustainable changes in residents' waste management behavior. Some studies have presented various approaches to improve resident-based education. Wang et al. (2018) recommended more informational campaigns and frequent information sharing using posters and social media to reach broader communities. However, Zheng et al. (2020) found that media advertising has no significant impact, and extensive advertising is not a solution. As Jiang et al. (2021) noted, advertising should serve as a communication channel to enhance willingness. Thus, it may become a support system rather than the primary educational approach. Pierini et al. (2021) proposed a relatively new strategy for resident-based waste management education through the concept of citizen science, while Pei (2019) and Zheng et al. (2020) emphasized local links, social cohesion, and social communications, which are heavily dependent on community empowerment for effective education. Chikowore (2020) considered active community participation as a behavioral change factor for sustainable waste management practices. Education is expected to build new habits (Liao et al., 2018; Xu et al., 2017). Unfortunately, many educational programs cannot ensure long-term participation; post-training participation rates decline (Zebu & Suhardini, 2021). Effective education can equip citizens with skills that enable them to participate effectively in waste management programs, including communication, coordination, and teamwork skills. Educational activities on such a scale require appropriate educational planning. The most important solution to realize this potential is the proper and systematic management of education. However, how can we avoid the ineffectiveness of the provided training while ensuring the effectiveness of educational programs? Standardizing educational processes is one of the innovative practices to enhance citizens' capabilities in waste management, thus adequately addressing audience needs and preventing unnecessary costs (Ebrahimi

Ghavam, 2013). Therefore, to successfully and sustainably implement civic education, it is essential to identify its components and design and validate an educational model; otherwise, the costs incurred may not be effective. Creating an appropriate educational model can improve intergroup communications in waste management and enhance cooperation between institutions and citizens. This research focuses on designing and validating a civic education model for sustainable participation in urban solid waste management. Many current approaches in civic education lack clear and practical models, and this study aims to address this gap by designing a specific model. Given the unique characteristics and needs of each community, this study can enhance the scientific and practical understanding of civic education and participation in waste management, leading to improved environmental quality and urban living.

Research Methodology

This research is exploratory in nature and applied, as well as developmental in terms of its objectives. In terms of data collection, a mixed-method approach (qualitative and quantitative) was employed in two parts.

Part One of the Research

In the qualitative section, the statistical population included books, scientific and research articles, available theses and dissertations in Persian and English, as well as semi-structured exploratory interviews with experts related to the research topic. In the document review phase, 320 studies were extracted from foreign and domestic databases, and in the initial evaluation, the titles and abstracts of all studies were reviewed to ensure that they were directly related to the topic. Studies that did not have a direct connection to these areas were excluded from further review. Given the importance of up-to-date research findings, the primary emphasis was on studies published after the year 2000. However, in a few rare cases, articles published before this date were retained in the review list if they had very high theoretical and methodological significance and were cited as references in the research. In the next phase, the content of these articles was carefully examined. The following criteria were considered in this review: reputable research works published in credible journals (with appropriate scientific ranking and acceptable impact factor). Articles that employed strong and appropriate research methodologies were selected. By applying these criteria and conducting a thorough screening process, 150 final articles were chosen as the basis for analysis in this research. In this section, using the meta-synthesis method and then through pattern and descriptive analysis via MAXQDA software version 2020, the classification of the identified components and indicators was performed. To ensure the reliability of the findings from the qualitative section of the research, reliability testing was conducted. In this step, to measure the reliability of this stage of the model design, the Kappa coefficient was used. For this purpose, to determine the reliability of the codings, the opinions of two different experts were utilized, and the results are detailed in Table 2.

Part Two of the Research

In the quantitative section of the research, the measurement tool was a researcher-made five-option questionnaire based on the Likert scale, prepared with reference to the theoretical field and research model. It was provided to 42 experts in environmental education, waste management, and environmental management using a purposive sampling method. Given the limitation of the specialized sample size, the sample size was evaluated using the acceptable capabilities of the PLS software for power analysis. After data collection, the analysis of results was conducted using structural equation modeling with a partial least squares approach. This method is noted for its superiority in small samples and is applicable in cases where the number of measurement items is low and the distribution of variables is not specified (Kock & Hadaya, 2018). The complete structural equation model consists of two parts: a measurement model that defines the relationships between latent variables and indicator variables (measured variables), and a structural model that considers a specific causal structure among the latent variables (Rashidi et al., 2020). To test the conceptual model of the research, the following model analysis algorithm was used, and necessary analyses

were conducted in two sections:

1. Model fit of measurement models, SEM, including the assessment of reliability and validity of the research constructs using three criteria:
   a) Reliability of each indicator,
   b) Composite reliability of each construct, and
   c) Average variance extracted;
2. Fit of the structural model; in this model fit, the relationships between latent variables were analyzed, and criteria such as t-values, R^2 effect size, F^2, and Stone-Geisser Q^2 were examined for the fit of the structural model.

Research Findings

The summary of the initial semantic units obtained from the interviews, as well as the integration of coding from the document studies and expert opinions, led to the extraction of components and indicators, which are presented below in Table 1.

Table 1. Components & Indicators Extracted from Document Review & Interviews

Component	Symbol	Item	Reference
Environmental awareness & knowledge	AK	Information about environmental issues	(Abubakar et al., 2022)
		Understanding natural resources & ecosystems	(Irawan & Hartoyo 2022)
		Impact of waste pollution	(Brotosusilo et al., 2020)
		Negative consequences of improper waste management	(Mwanza et al., 2018, Rautela et al., 2021)
Education methods	TM	Workshops	(Zhou et al., 2022)
		Educational programs in schools & universities	(Kabirifar et al., 2020)
		Online education & digital resources	(Gustiani, 2020, Barrot et al., 2021)
		Seminars & conferences	(Stephen & Rockinson-Szapkiw, 2021)
Type of education	TT	Direct or informal citizenship education	(Gericke et al., 2020, Khoo & Jørgensen, 2021)
		Implicit or supplementary education in citizenship practices	(Coopmans et al., 2020, Santoso et al., 2022)
		Formal education	(Gericke et al., 2020)
Media & communication	MC	Use of social media	(Zorpas, 2020, Jiang et al., 2021)
		Advertising campaigns	(Kala & Bolia, 2020, Shi et al., 2020)
		Television & radio programs	(Molina & Catan, 2021, Uhunamure et al., 2021)
		Local brochures & publications	(Agyeiwaah, 2020)
Infrastructure & practical facilities		Volunteer activities in nature	(Raza et al., 2021)
		Ease of access to information & educational resources	(Debrah et al., 2021)
		Visits to educational & environmental centers	(Bahçelioğlu et al., 2020)
		Conservation & recycling projects	(Ma & Zhang 2020)
		Providing waste separation bins in different parts of the city	(Rathore et al., 2020)
		Establishing recycling stations	(Yousefloo & Babazadeh, 202)
		Providing regular waste collection services	(Pardini et al., 2020, Sohag & Podder, 2020)

Component	Symbol	Item	Reference
Encouragement & motivation	E	Providing awards & rewards to active citizens	(Suryawan & Lee, 2023)
		State & local support for waste management projects	(Khan & et al. 2022)
		Encouraging community-based initiatives by setting up small businesses	(Cai et al., 2020, Vives, 2022)
		Holding waste separation competitions & challenges	(Viljoenet al., 2021)
		Allocation of a portion of recycling revenues to beautify neighborhoods & build parks & informing citizens	(Afshar et al., 2021, Lee & Harris, 2024)
		Financial return systems for recycling	(Zhou et al., 2021)
Social support	SC	Formation of local groups & associations	(Knickmeyer, 2020)
		Volunteer activities to clean up areas	(Battisti et al., 2020, John & et al., 2020)
		Holding mass events such as Earth Day	(Rosalyn & Kurniawan, 2019, Tariska et al., 2021)
		Civic culture	(Billore, 2021, Sewak et al., 2021)
		Cooperation with non-governmental organizations	(Botha, 2018, Arantes et al., 2020)
Culture building & behavior change	CB	Promoting a culture of waste separation through art & media	(Lou et al., 2022, Maiurova et al., 2022)
		Encouraging sustainable behaviors (such as waste separation)	(Knickmeyer, 2020, Razali et al., 2020)
		Social & cultural values in the field of environmental protection	(Zorpas, 2020, Nguyen & Jones, 2022)
		Using successful role models to inspire others	(Sharma et al., 2020, Chauhan et al., 2021)
Policy & laws	R	Environmental protection laws	(Zorpas, 2020, Guo et al., 2021)
		Regulation & approval of new laws, measures & guidelines to promote proper municipal waste management	(Guerrero et al., 2013, Hassan et al., 2021)
		Monitoring the implementation of laws & policies	(Agboola et al., 2020,Kumar & Agrawal, 2020)
		Government programs for education & awareness	(Debrah et al., 2021, Abubakar et al., 2022)
		Financial support for educational & local waste management projects	(Debrah et al., 2021, Fadhullah et al., 2022, Kharola et al., 2022)
Social experience & interactions	SE	Positive or negative experiences from previous participation	(Reed et al., 2018, Asiaei et al., 2022)
		The influence of friends, family & neighbors on the individual's attitude	(Shen et al., 2019, Luoet al., 2020)
Sustainable public participation	P	Individual & demographic characteristics	(Esmaeilian, Wang et al., 2018, Knickmeyer, 2020)
		Intention & intention to participate	(Khan, Ahmed et al., 2019, Saeed et al.,2019)
		Public-private-public partnership	(Kang et al., 2019, Aning-Agyei, 2020)
		Possibility of participation (legal status, conditions & facilities)	(Esmaeilian et al., 2018, Hettiarachchi et al., 2018)

Component	Symbol	Item	Reference
Government support	GS	Change in levels of urban management	(Qu et al., 2019, Ch&rappa & Das, 2024)
		Election of urban councils & local councils	(de Castro et al., 2019, Leach, 2019, Mostovoy et al., 2021)
		Constructive interaction between municipalities & local authorities with other associations, institutions & government & non-governmental community-based organizations with citizens	(Botha, 2018, Nwankwo, 2022, Mesoe, 2023)
		Planning, organizing & securing the necessary financial resources	(Otoo & Drechsel, 2018, Zietlow et al., 2018)

To calculate the reliability of the designed model in this research, the Kappa coefficient was used. According to Gwet (2014), an acceptable Kappa value is above 0.6, and a value higher than 0.8 is considered ideal for agreement between two evaluators. In this research, the Kappa coefficient was found to be 0.95, indicating that it possesses valid reliability, demonstrating excellent reliability of the model. The reliability levels of the Kappa coefficient are detailed in Table 2.

Table 2. Reliability Levels of the Kappa Coefficient (Gwet, 2014)

Statistical results (Kappa agreement coefficient)		Numerical value	Agreement status
Value	0.95	0>	Weak
		0.0- 0.02	Non-significant
		0.21- 0.4	Average
		0.41- 0.6	Adequate
		0.61- 0.8	Reliable
		0.81- 1	Excellent

A Conceptual Model of Citizenship Education to Attract Sustainable Participation in Municipal Solid Waste Management

The sunburst model is a visual representation that shows hierarchical data in a circular format and is commonly used to display relationships and proportions. In the context of environmental education modeling for citizens, this tool can be a powerful means to represent and analyze various factors affecting environmental issues, stakeholders, and the relationships among different educational aspects. The sunburst chart provides a clear and engaging way to display the multiple facets of environmental education, making it a valuable tool for educators, planners, and policymakers in the fields of environmental literacy and sustainability. To present a comprehensive approach to the civic education model for sustainable participation in urban solid waste management, the conceptual model derived from the literature analysis is shown in Figure 1.

Findings of the Quantitative Section: Introduction of the Structural Modeling Questionnaire with PLS

In this research, after designing the qualitative model, the final PLS model questionnaire was prepared, consisting of 12 components and 53 items, and was reviewed by experts. Out of the distributed questionnaires, 42 individuals responded. To assess the appropriateness of the collected data for conducting factor analysis and to identify the correlation matrix (data adequacy significance), the KMO coefficient and Bartlett's test were utilized.

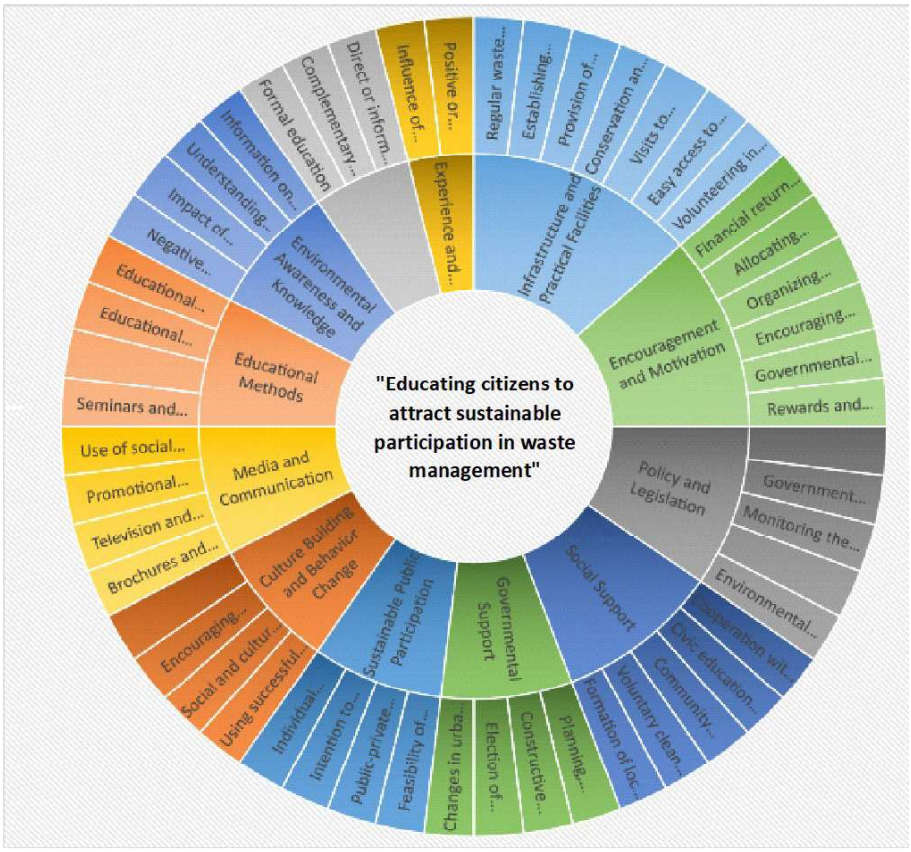

Figure 1. Conceptual Model of the Research

Table 3. KMO Statistics, Bartlett's Test, & Significance Level

KMO coefficient	Bartlett's sphericity statistic	Degree of freedom	Significance
0.836	264.938	15	0.000

The KMO statistic measures the adequacy of variables, with values ranging between 0 and 1. If your KMO is 0.70 or higher, it is generally considered that your sampling is adequate for factor analysis. Based on the results in Table 3, the KMO coefficient is 0.836, indicating that the sample sizes are adequate for the current research. Bartlett's test examines whether there is sufficient correlation among the variables to justify factor analysis. If the computed significance level (sig) of Bartlett's test is less than 0.05, factor analysis is appropriate for identifying the structure (factor model), and the necessary condition for conducting factor analysis is met, as the hypothesis of a single correlation matrix is rejected. As shown in Table 3, the value of Bartlett's test is 264.938 and is significant at the 0.000 level. Therefore, considering that the KMO index is above 0.7 and that the significance level of Bartlett's test is less than the 5% significance level, it can be concluded that the data are suitable for factor analysis.

Fit of Measurement Models

According to the model analysis algorithm, two criteria—reliability and validity—were used to examine the fit of the measurement models. To assess the reliability of the measurement models, the criteria of factor loading coefficients, Cronbach's alpha, and composite reliability were calculated as follows:

Table 4. Results of Cronbach's Alpha, Composite Reliability, & Average Variance extracted

Structure	Cronbach's alpha (Alpha > 0/7)	Combined Reliability (CR) (CR > 0/7)	Average variance extracted (AVE>/5)
Awareness & knowledge	0.891	0.739	0.520
Government support	0.961	0.972	0.972
Model	0.902	0.914	0.914
Media & communication	0.697	0.744	0.744
Participation	0.736	0.737	0.831
Scientific infrastructure	0.829	0.876	0.876
Policymaking & laws	0.756	0.772	0.772
Social experiences & interactions	0.739	0.777	0.777
Social supports	0.881	0.914	0.914
Education methods	0.735	0.681	0.681
Type of education	0.734	0.748	0.519
Culturalization	0.730	0.668	0.668
Encouragement & motivation	0.701	0.910	0.536

In the present research model, the Cronbach's alpha value for all components was calculated to be above 0.7, indicating that all variables possess adequate reliability, which reflects the suitable internal consistency of the measurement models.

According to the findings in Table 4, the composite reliability for all variables in the model was calculated to be above 0.8, indicating good internal reliability of the model. Additionally, based on the results in Table 4, the convergent validity across all constructs in the model is above 0.5, thus confirming the discriminant validity of the model.

Measurement of Factor Loadings

The factor loading values and path coefficients are also shown in Figure 2. In this model, all factor loadings are evaluated to be at a very desirable level, except for one of the efficiency items, which is rated as acceptable.

Fit of the Structural Model

The Q^2 & R^2

According to the values in Table 5, the coefficient of determination R2 for all model constructs is evaluated as significant, confirming the suitability of the structural model fit. Furthermore, according to the values in Table 5, since the obtained values are above the threshold of 0.35, this indicates a strong predictive power of the model, further affirming the good fit of the structural model of the research. The highest predictive power is related to the construct of media and communication.

Table 5.Coefficient of Determination Values

Structure	R^2	Q^2
Policy & Law	0.612	0.472
Media & Communication	0.808	0.718
Social Support	0.386	0.520
Awareness & Knowledge	0.514	0.320
Participation	0.856	0.419
Encouragement & Motivation	0.320	0.352
Education Methods	0.277	0.353
Type of Education	0.757	0.504
Culture Building	0.673	0.350
Practical Infrastructure	0.797	0.319
Social Support	0.857	0.345
Government Support	0.801	0.445

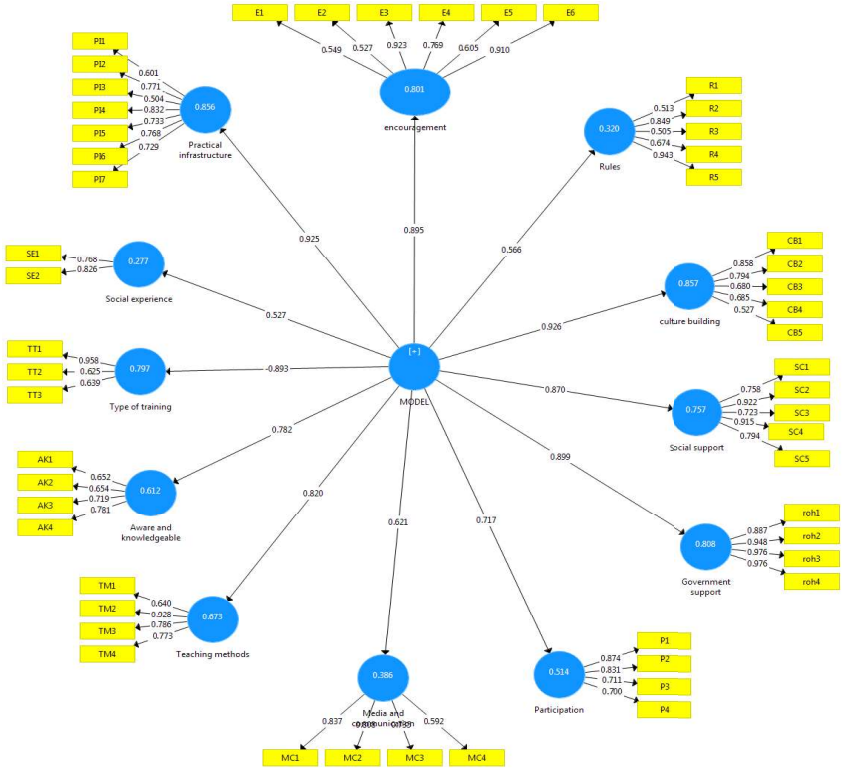

Figure 2. Factor Loadings and Path Coefficients in the Structural Equation Model

Suitability of the Structural Model

Effect Size Measure F^2, This measure determines the strength of the relationship among the constructs in the model. According to Cohen, values of 0.02, 0.15, and 0.35 represent small, medium, and large effects, respectively. For each effect in the model path, the effect size can be evaluated using Cohen's F^2. Based on the values in Table 6, the F^2 values for all constructs are large, with the greatest effect related to the construct of participation.

Table 6. Effect Size

Structure	Awareness & Knowledge	Government Support	Media & Communication	Participation	Participation	Policy & Law	Social Experiences & Interactions	Social Support	Education Methods	Type of Education	Culturalization	Encouragement & Motivation
Model	1.577	4.206	0.629	1.06	5.926	0.471	0.384	3.123	2.057	3.92	5.971	4.036

Hypothesis Testing,

According to the data analysis algorithm in the PLS method, after evaluating the fit of the measurement and structural models by examining the significance coefficients Z (t-values) of each path and the standardized factor loadings related to the paths, the research hypotheses are tested. In terms of the absolute size of the coefficients, various references indicate that coefficients greater than 0.1

signify an effect in the path. If the significance coefficient is greater than 1.96, the path coefficients and the hypothesis of the relationship between the constructs in the model are confirmed at a 95% confidence level. To assess the significance of the path coefficient, the t-value of each path must also be considered. According to Table 7, since the t-values of the coefficients for each path are above 1.96, at a 95% confidence level, the predicted paths are significant, and all research hypotheses regarding the existence of relationships among the constructs are confirmed.

Table 7. T-Statistic Values & Results of Hypothesis Testing at 95% Confidence Level

Path	T-Statistic	P Values
Model-----> Awareness & Knowledge	20.284	0.000
Model-----> Government Support	24.927	0.000
Model-----> Media & Communications	8.863	0.000
Model-----> Participation	10.195	0.000
Model-----> Scientific Infrastructure	62.551	0.000
Model-----> Policymaking & Laws	1.036	0.000
Model-----> Social Experiences & Interactions	4.227	0.000
Model-----> Social Support	37.869	0.000
Model-----> Training Methods	26.803	0.000
Model-----> Type of Training	10.828	0.000
Model-----> Culture Building	2.808	0.000
Model-----> Encouragement & Motivation	4.181	0.000

Conclusion

To address the research question, a systematic review method was employed, utilizing a meta-synthesis of documentary studies and interviews. Using MAXQDA software, the components and indicators of the civic education model for sustainable participation in urban solid waste management were identified and clarified. It was determined that a total of 12 components were identified: environmental awareness and knowledge, teaching methods, type of education, media and communication, infrastructure and practical facilities, encouragement and motivation, social support, cultural change and behavior modification, policy-making and legislation, social experiences and interactions, sustainable public participation, and governmental support, along with 53 indicators.

Previous studies have also utilized solar models for simulating and educating citizens about environmental issues. For example, Ariza et al. (2021) examined the impact of solar models on citizen education regarding waste management and environmental awareness. The researchers demonstrated that using solar models could lead to increased citizen participation in environmental activities. Similarly, Morgan et al. (2023) explored the use of complex models to simulate citizen behavior concerning environmental issues, showing that solar models can serve as effective tools for public education and engagement. Bennett and Roth (2018) investigated the role of education in natural resource management and the use of solar models for public education on environmental conservation. Altassan (2023) studied the impact of educational programs based on solar models on environmental behaviors in local communities.

It is noteworthy that the identified influential factors in this research interact with one another, and the contribution of each is significant to the success of the educational model. Therefore, to provide effective and sustainable education in waste management, the role of all these factors must be considered.

Subsequently, in response to the research question, the validation of the model was analyzed using expert opinions and PLS software. The validation assessments indicated that the designed model is comprehensive, suitable, and implementable, possessing the necessary fit. As the research results show (Table 5), considering the obtained value for Q^2 or the predictive power of the model, one of the most important components is media and communication. The findings of this section of the research align with previous similar studies

regarding the impact of media and communication in civic education and waste management (Karami Darabkhani, 2019), thus confirming the results.

A limitation of this research was the lack of access to specialized experts. Based on the research results, it is recommended that educational specialists intervene in the educational planning and design of waste management in municipalities, train the necessary human resources, and develop electronic training infrastructures for civic education. Additionally, it is suggested that, alongside educational management, other main variables such as organizational structures, learning culture among citizens, learning motivations, psychological interventions, managerial support, individual differences, and demographic variables should also be examined in explaining the phenomenon of educational productivity among citizens. Furthermore, evaluation indicators for the training provided in the field of waste management and citizen participation should be designed.

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