Practical Perception and Quality Evaluation for Teaching of Dynamic Visual Communication Design in the Context of Digital Media

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Abstract—In the age of the Internet, the teaching of dynamic visual communication design (DVCD) is an irresistible trend for the innovation of visual art teaching. The DVCD teaching quality can be improved to a new level by providing feedbacks to applications with the data on students' needs for practical perception (PPN). However, the current practical perception and service applications rarely tackle the feature extraction and application of high-level needs for practical perception in the context of digital media. To solve the problem, this paper explores the practical perception and quality evaluation for DVCD teaching in the context of digital media. Specifically, the students' PPN feature extraction problem was described in the field of DVCD teaching, and fuzzy clustering was introduced to extract students' PPN features. Then, the authors detailed the dynamic evolution of students' PPN in the context of digital media, and selected multiple layers of evaluation indices for DVCD teaching quality. Finally, the evolution drivers and patterns of students' PPN were demonstrated, and the distribution of teaching quality scores was obtained through experiments.

Keywords—teaching of dynamic visual communication design (DVCD), the context of digital media, practical perception, teaching quality evaluation

1 Introduction

In the context of digital media, dynamic visual communication design (DVCD) is an artistic form relying on the new forms of visual design and new media technology [1-5]. The DVCD teaching in that context integrates the knowledge of multiple disciplines (arts, technology, and humanities) into the teaching contents of DVCD. This is an irresistible trend for the innovation of visual art teaching in the age of the Internet [6-14].

The rapid development of computer technology and the popularity of wireless communication technologies make it possible to precisely perceive students' learning needs. Thanks to the improvement of hardware, mobile devices can collect and process the usage information of the context of digital media, and support DVCD learning with the context of digital media [15-23]. The data on students' needs for practical perception (students' PPN) can be fed back to applications to inspire new teaching contents and models, bringing the DVCD teaching quality to a new level.

Ou [24] designed a remote network teaching system for visual communication courses. The system consists of five modules: a visual design case library, online courses, design projects and exhibits, design practice and exchange, and system management. In the system, teachers are responsible for providing knowledge and resources, while students can acquire knowledge and exchange their ideas. Jian [25] deeply analyzed the influence of design competition on the teaching reform of the major of visual communication design, and concluded that the students under the design competition teaching model performed much better than those under the traditional teaching model. Their research clarifies the direction for reforming the major of visual communication design.

The existing software can interactively visualize volume datasets. Bao et al. [26] introduced a network-based teaching software called VolumeVisual, which realizes volume visualization of teaching and learning. A formal user investigation was carried out to evaluate the effectiveness of the software. The specific steps include introduction, training courses, surveys, and testing. The proliferation of information technology in education causes an exponential growth of our abilities for information generation and acquisition. Chen and Liu [27] attempted to support in-depth learning by analyzing massive information, and to improve the display of teaching contents and optimize teaching process by information technology. It was concluded that information visualization must cover the following steps: acquisition, analysis, filtering, mining, expression, modification, and interaction. Nov'kov et al. [28] evaluated the design teaching and communication in architectural education, and investigated their implementation in different stages of building studio education.

In the context of digital media, most of the existing practical perception services target the physical data on the surface context of digital media, and rarely tackle the feature extraction and application of high-level needs for practical perception. To solve the problem, this paper explores the practical perception and quality evaluation for DVCD teaching in the context of digital media. The main contents cover the following aspects: (1) Section 2 describes the students' PPN feature extraction problem in the field of DVCD teaching, and extracts students' PPN features through fuzzy clustering. (2) In the context of digital media, the dynamic evolution of students' PPN was described in details. (3) Multiple layers of evaluation indices were selected for DVCD teaching quality, including reliability, degree of update, correctness, completeness, and importance. Finally, the evolution drivers and patterns of students' PPN were demonstrated, and the distribution of teaching quality scores was obtained through experiments.

2 Modeling and evaluation flow

Drawing on the existing theories and models, this paper designs an integrated model for practical perception and quality evaluation of DVCD teaching. The model mainly encompasses the extraction of PPN features, the dynamic evolution mechanism of PPN, and practical perception prediction. The purpose is to test the relationship between the students' PPN and satisfaction of DVCD teaching quality in the context of digital media. Figure 1 shows the structure of the practical perception and quality evaluation model for DVCD teaching.

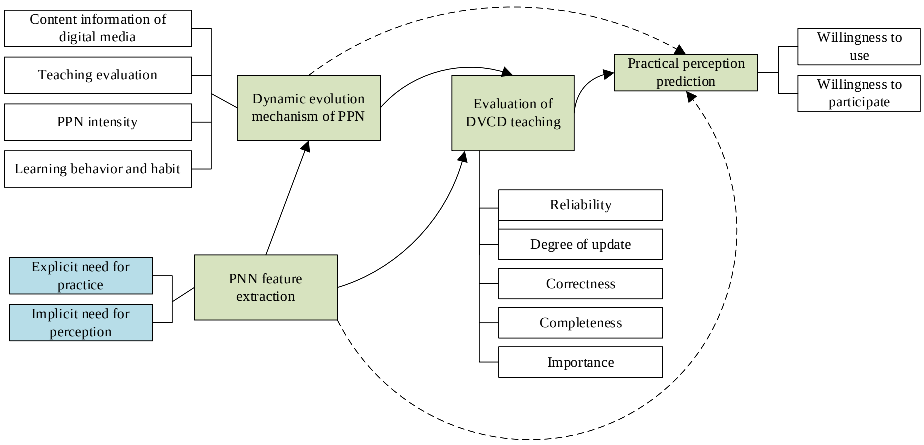

Fig. 1. Practical perception and quality evaluation model for DVCD teaching

Figure 2 shows the target framework of practical perception system in the context of digital media. The target layer contains the target of the entire system: Based on the media of teacher-student interaction during the teaching process, the information on the context of digital media is combined with learning behavior to analyze the dynamic evolution mechanism of students' PPN, thereby improving the student satisfaction with DVCD teaching quality.

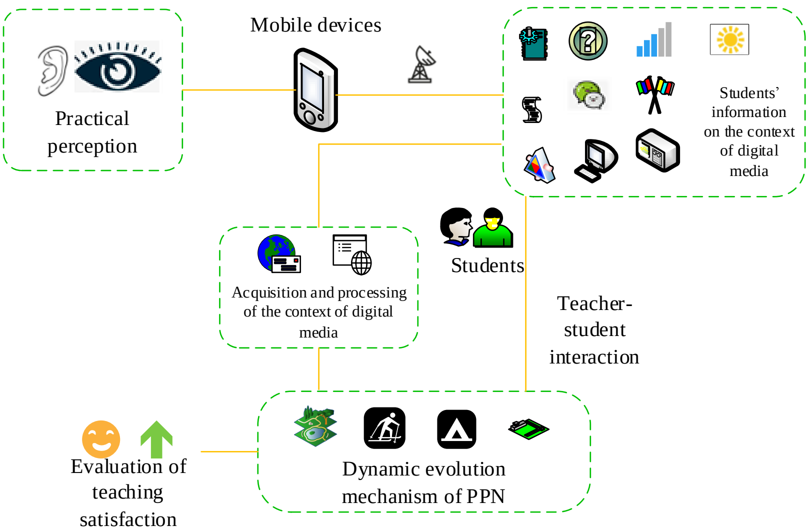

Fig. 2. Target framework of practical perception system in the context of digital media

3 Feature extraction

This paper carries out descriptive analysis on the feature extraction of students' PPN in the field of DVCD teaching. After defining the context of digital media and students' practical perception, the authors employed fuzzy clustering to extract the students' PPN features corresponding to different contexts of digital media, which provides support to the acquisition of students' PPN in the context of digital media.

The PPN features refer to the learning needs of students in the context of digital media, including both explicit need for practice and implicit need for perception. This section adopts the fuzzy clustering algorithm to cluster the students' PPN data in DVCD teaching. The resulting clusters of PPN features lay the basis for examining the dynamic evolution mechanism of PPN.

The fuzzy clustering algorithm determines the cluster centers of PPN features based on the minimum of the following objective function:

$$OB(T,D)=\sum_{i=1}^{d}OB_i=\sum_{i=1}^{d}\left(\sum_{i=1}^{d}t_{ji}^{n}E_{ji}^{2}\left(A_j,D_i\right)\right),1\leq n\leq\infty \tag{1}$$

Let A and A_j be the PPN vector set of a neighborhood, and the j-th input vector, respectively; D and d be the set of PPN cluster centers, and the total number of clusters, respectively; T and t_i be the PPN membership matrix, and the membership of the j-th PPN vector in the i-th PPN class, respectively; n be the fuzzy number controlling the PPN clustering effect. Then, the element value t_{ji} of the membership matrix can be calculated by:

$$t_{ji} = \frac{1}{\sum_{r=1}^{d} \left(\frac{\left\| A_j - D_i \right\|}{\left\| A_j - D_r \right\|} \right)^{\frac{2}{n-1}}} \tag{2}$$

The cluster center D_i can be calculated by:

$$D_i = \frac{\sum_{j=1}^{m} t_{ji}^{n} A_j}{\sum_{j=1}^{m} t_{ji}^{n}} \tag{3}$$

Let A_{jn} and D_{in} be the n-th dimension of the j-th PPN vector, and the i-th cluster center, respectively. Then, the distance $E_{ji}=(A_j,D_i)$ from the j-th PPN vector point to the i-th PPN class center can be expressed as:

$$E_{ji} = \left(A_j, D_i\right) = \sqrt{\left(A_{j1}, D_{i1}\right)^2 + \left(A_{j2}, D_{i2}\right)^2 + \ldots + \left(A_{jn}, D_{in}\right)^2} \tag{4}$$

An important constraint of the fuzzy clustering algorithm is that the memberships of all PPN vectors to their classes add up to 1. The cumulative sum of the memberships can be calculated by:

$$\sum_{i=1}^{d} t_j = 1, \forall t_{ji} \in [0,1], j = 1, 2, \ldots, m, 0 < \sum_{j=1}^{m} t_{ji} < m \tag{5}$$

When the difference between T or the distance between D is smaller than the preset threshold σ. The fuzzy clustering algorithm will end, and output the final clustering results of PPNs.

Through fuzzy clustering, it is possible to obtain the relationship between different contexts of digital media and PPN features (Figure 3).

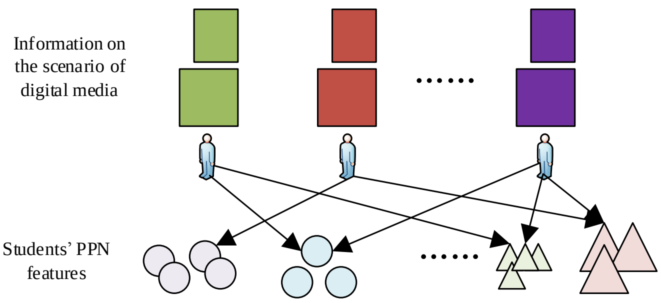

Fig. 3. Relationship between scenario and PPN features

4 Dynamic evolution mechanism

In the context of digital media, the core of DVCD teaching is to discover and predict students' PPN, and provide the learning resources according to the PPN. The constant changes of students' PPN significantly affect the teaching quality.

In this paper, the dynamic evolution of PPN refers to the PPN dynamics of the students in DVCD learning in the context of digital media. The PPN evolution arises from various reasons. In the context of digital media, the evolution of students' PPN is highly dynamic. In summary, there are four drivers of students' PPN evolution, namely, the information on the context of digital media, teaching evaluation, PPN intensity, and learning behavior and habit.

Specifically, the information on the context of digital media refers to the scenario of DVCD learning, i.e., the knowledge information from various disciplines, including media technology, design art, computer graphics, visual art, etc. Teaching evaluation stands for the score of PPN satisfaction rated by the students in the current context of digital media. The PPN intensity refers to the frequency of the students participating in the teaching activities satisfying the current PPN in different contexts of digital media. The learning behavior and habit stand for the PPN frequently appearing due to the learning habit in the current context of digital media. The above four elements constitute the basic unit of student's PPN evolution.

The PPN habit is the set of PPNs frequently appearing due to the long-term learning method and learning habit: $UF=\{e_{w1},e_{w2}, ...,e_{tn}|w\in W\}$, where e_{wi} is the i-th PPN of a student in the context w of digital media.

The change rate $u_{w,mi}$ of explicit PPN represents the variation of explicit PPN m_j of student v_i in the context w of digital media. Let $U(v_i,m_j,w)$ be the number of appearances of PPN m_j of student v_i in the context w of digital media during a period; $U^*(v_i,m_j,w)$ be the mean number of appearances of all PPNs M of student v_i in the context w of digital media during a period. Then, $u_{w,mi}$ can be calculated by:

$$u_{w,m_i}=\frac{U\left(v_i,m_j,w\right)-U^*\left(v_i,M,w\right)}{U^*\left(v_i,M,w\right)} \tag{6}$$

The change rate $ue_{vi,mi}$ of implicit PPN represents the variation of implict PPN m_j of student v_i in the context w of digital media. Let $U(v_i,m_j,hr_n)$ be the scores rated by student v_i for implicit PPN hr_n of PPN m_j; $U^*(v_i,m_j,hr_n)$ be the mean score rated by student v_i for implicit PPN hr_n of PPN m_j; N, and M be the dimensionality of implicit PPN, and number of apparencies of PPN m_j, respectively. Then, $ue_{vi,mi}$ can be calculated by:

$$ue_{v_i,m_i}=\frac{1}{N}\sum_{m_i\in N,M}\frac{U\left(v_i,m_j,hr_n\right)-U^*\left(v_i,m_j,HR_n\right)}{U^*\left(v_i,m_j,HR_n\right)} \tag{7}$$

The change rate $XB_{w,vi,mj}$ of students' PPN reflects the overall variation of PPN m_j of student v_i in the context w of digital media. Let $CA_{w,mj,CHA}$ and $HD_{w,mj,CHA}$ be the variation of explicit PPN and implicit PPN, respectively; β and α be the weights of explicit PPN and implicit PPN, respectively, which are determined through experiments. Then, $XB_{w,vi,mj}$ can be calculated by:

$$XB_{w,v_i,m_j} = \beta\left|CA_{w,m_j,CHA}\right| + \alpha\left|HD_{v_i,m_j,CHA}\right| \quad (8)$$

This paper details the dynamic evolution of students' PPN in the context of digital media:

Step 1. Process students' PPN information

The PPN in the field of DVCD teaching, and the information on the context of digital media are described and defined. The perception data are processed to obtain the PPN vector in each context of digital media.

Step 2. Mine the students' PPN habit.

The frequent pattern growth (FP-Growth) algorithm is called to mine the PPN habit of each student in each context of digital media. Let $CO(a,b)$ be the number of cooccurrences of PPNs a and b; M be the number of PPNs. Then, the support and confidence can be calculated respectively by:

$$SUP\left(a \to b\right) = \frac{CO\left(ab\right)}{M} \quad (9)$$

$$CONF\left(a \to b\right) = \frac{CO\left(ab\right)}{CO\left(a\right)} \quad (10)$$

Step 3. Acquire students' PPN habit.

The students' PPN mined in the previous step is sorted out to obtain the PPN habit set $UF=\{uf_{w1},uf_{w2}, ...,uf_{tn}|w\in W\}$.

The change rate of students' PPN is compared with the preset threshold XB_{TH} to see if the student PPN may change. If $XB_{w,vi,mj}>XB_{TH}$, the student's PPN will change; if $XB_{w,vi,mj}<XB_{TH}$, the student's PPN will not change. Normally, the change threshold of students' PPN is determined by experience and the actual situation. Let $(CA_{w,mi})'$ and $(CA_{w,mi})''$ be the current and previous change rates of explicit PPN, respectively; $(HD_{vi,mi})'$ and $(HD_{yi,mi})''$ be the current and previous change rates of implicit PPN, respectively. Then, we have:

$$CA_{w,m_j,CHA} = \left(CA_{w,m_j}\right)' - \left(CA_{w,m_j}\right)'' \quad (11)$$

$$HD_{v_i,m_j,CHA} = \left(HD_{v_i,m_j}\right)' - \left(HD_{v_i,m_j}\right)'' \quad (12)$$

5 Teaching quality evaluation

The evaluation of DVCD teaching quality helps to optimize the design of teaching contents and scenarios in the context of digital media, and provides a necessary reference for innovative application of intelligent practical perception techniques. Based on the dynamic evolution of students' PPN, many evaluation indices are available for DVCD teaching quality. The most popular indices include reliability, degree of update, correctness, completeness, and importance.

Reliability refers to the degree of credibility for the usage information for the context of digital media. This student-related parameter is objective, and independent of the usage information. It is often applied to depict the selection of teaching contents/resources in the same context of digital media. Let ξ be the precision of information acquisition; $\Phi(r,\sigma)$ be the distance between usage information for the context of digital media; Φ_{max} be the maximum distance from the usage information to the trusted object. Then, reliability can be calculated by:

$$RE=\begin{cases}1-\dfrac{\Phi(r,\sigma)}{\Phi_{max}}\times\xi,\ if\ \ \Phi(r,\sigma)<\Phi_{max}\\ 0,\ Otherwise\end{cases} \tag{13}$$

The higher the ξ, the greater the reliability, and the more credible the collected usage information for the context of digital media.

The degree of update refers to the freshness of the usage information for the context of digital media in a fixed period. Let TG be the time difference of the usage information from the time of measurement to the current time; LI be the preset threshold for the maximum period for the usage information to be effective. Then, the degree of update can be calculated by:

$$UTD=\begin{cases}1-\dfrac{TG}{LI},\ if\ \ TG<LI\\ 0,\ Otherwise\end{cases} \tag{14}$$

The greater the TG, the smaller the degree of update.

Correctness refers to the proportion of the realistic usage information for the context of digital media in the total usage information. Let M_T be the number of realistic usage information; M_Z be the total number of usage information. Then, the correctness can be calculated by:

$$COR=\frac{M_T}{M_Z} \tag{15}$$

Completeness refers to the information volume contained in the teaching contents and scenarios in the context of digital media, and reflects the sufficiency of the utilizable information in that context. It is the ratio of the utilizable information volume to the total information volume in the context of digital media. Let N_I be the utilizable information volume; M_T be the total information volume; ω_i be the weight of the i-th attribute of the object. Considering the weight of each utilizable information volume, the completeness can be calculated by:

$$COM = \frac{\sum_{j=0}^{N_I} \omega_j}{\sum_{i=0}^{M_T} \omega_i} \tag{16}$$

Importance refers to the value of teaching contents and scenarios in the context of digital media. Let LJ be the critical value for the teaching contents and scenarios in that context; LJ_{max} be the maximum critical value for the teaching contents and scenarios that are distributable to a type of context of digital media. Then, the importance can be calculated by:

$$importance = \frac{LJ}{LJ_{max}} \tag{17}$$

6 Experiments and results analysis

This paper firstly tests the usability of each context of digital media. The results in Table 1 show that the different contexts of digital media on average completed more than 95% of teaching tasks. Most students can smoothly complete the teaching tasks in the context of digital media. The satisfaction is mainly affected by the experience on the needs for targeted, personalized applications. The mean score of 80.5 demonstrates that different contexts of digital media are highly usable in DVCD teaching tasks. After the usability test, retrospective interviews were conducted on the students to summarize their feedbacks on different contexts of digital media. It was learned that the confusion in the practice of the context of digital media mainly stems from the difficulty in quickly classifying the contexts.

Table 1. Usability test results on contexts of digital media

Media number	Media 1	Media 2	Media 3	Completion rate	Score
1	43.06	12.48	43.95	98%	91
2	36.92	56.93	146.08	95%	83
3	22.48	215.24	53.41	92%	84.9
4	28.16	131.82	117.62	97%	76.2
5	19.08	168.47	55.94	99%	73
6	32.61	11.49	50.08	96%	70.5
7	48.27	146.93	117.39	96%	78.4
8	35.09	225.81	56.37	95%	83
Mean	35.47	156.72	54.13	98%	85

According to the classes of the contexts of digital media, the contents and scenarios of DVCD teaching were illustrated, and the students were asked to rank these factors by importance, in the light of their practical cognition. Figure 4 shows the importance distirbution of the information on the contexts of digital media. The distribution needs to be further quantized during the collection and statistical analysis on the information of the context of digital media.

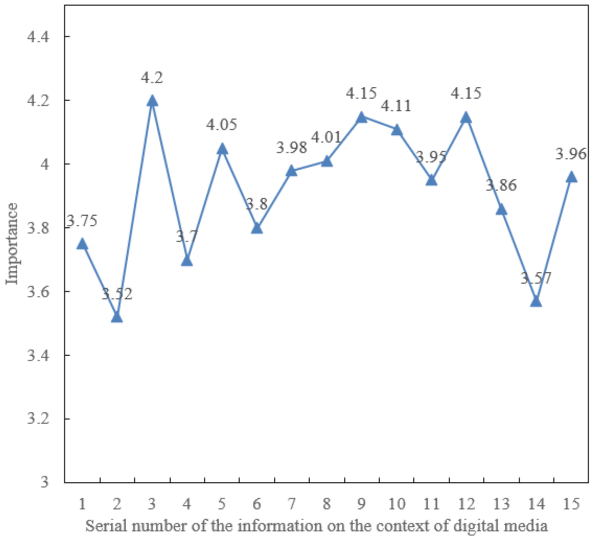

Fig. 4. Importance distirbution of the information on the contexts of digital media

Figure 5 shows the PNN oscillations of students in a specific context of digital media, in the course of DVCD learning. A high PPN variation means the PPN tends to increase in that context; A negative PNN variation means the PPN is negligible in that context.

Figure 6 shows the drivers and patterns of students' PNN evolution. It can be seen that, during DVCD learning, the students prefer relatively clear PPN. In addition, the students will learn the knowledge in line with their learning behavior and habit, in the course of DVCD learning, and are inclined to autonomously explore different contexts of digital media. Hence, the students learning DVCD may adopt the method and choose to learn the contents, which are recommended by teachers, or required by PPN, and thereby achieve a high satisfaction with the teaching quality.

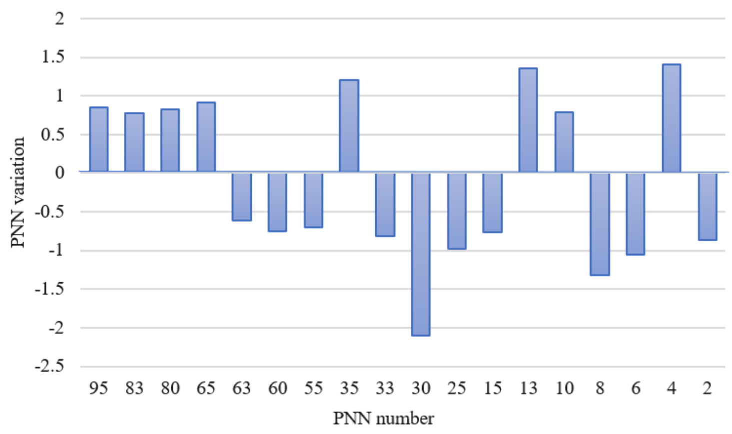

Fig. 5. PNN oscillations

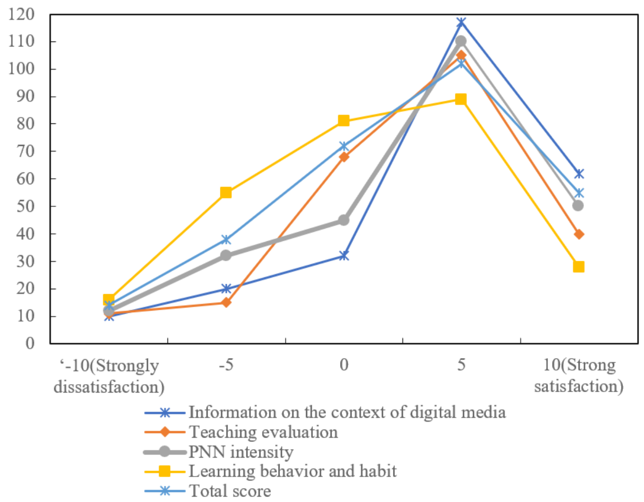

Fig. 6. Drivers and patterns of students' PNN evolution

Finally, DVCD teaching quality was evaluated in terms of reliability, degree of update, correctness, completeness, and importance. Figure 7 presents the distribution of teaching quality scores. It can be seen that the students were generally very satisfied with DVCD teaching. The main reason is that the usage information of the context of digital media can be acquired anytime, anywhere, and the information is credible, fresh, and realistic. In addition, the teaching contents and teaching scenarios contain sufficient information with high learning values. These factors should be fully considered in DVCD teaching design to encourage students to actively participate in DVCD teaching activities.

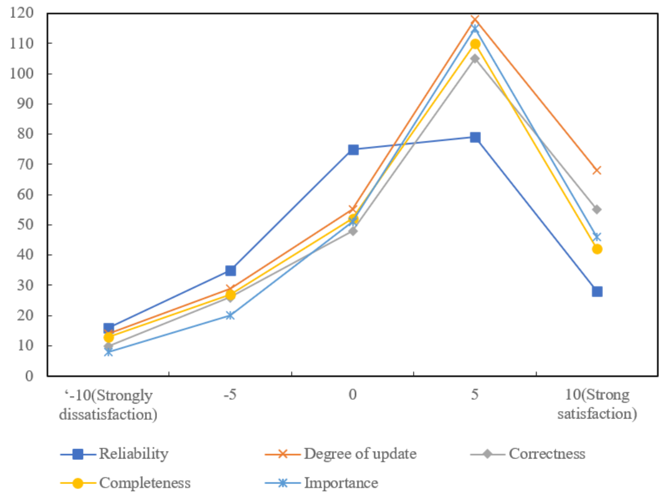

Fig. 7. Distribution of teaching quality scores

7 Conclusions

This paper studies the practical perception and quality evaluation for DVCD teaching in the context of digital media. After depicting the students' PPN feature extraction problem in DVCD teaching, the authors adopted fuzzy clustering to extract students' PPN features, and detailed the dynamic evolution of students' PPN in the context of digital media. Next, multiple layers of evaluation indices were introduced for DVCD teaching quality. Through experiments, the authors tested the usability of the contexts of digital media, and found that the confusion in the practice of the context of digital media mainly stems from the difficulty in quickly classifying the contexts. Further experiments revealed the importance distribution of the information on the context of digital media, the oscillations of PPN, and the drivers and patterns of students' PPN evolution. The results show that, during DVCD learning, the students prefer relatively clear PPN. Finally, the DVCD teaching quality was evaluated from the angles of reliability, degree of update, correctness, completeness, and importance.

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