Electronic Supplementary Material (ESI) for Chemistry Education Research and Practice

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Rubric for text- and illustration-based evaluation of textbooks. (PDF, 6 pages, 145 KB).

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Table S1
Rubric for text- and illustration-based evaluation of textbooks

Analysis Areas	Possible Scores		Description within NPs	Description within FPs	Rationale & Alignment to Principles
Introduction of the Projection					
Purpose	0	The purpose of the diagram is not discussed at its introduction	The diagram is introduced only as a possible way to represent a molecule	The diagram is introduced only as a possible way to represent a molecule	*Principle 1:* As instructors, we feel it necessary that students are told why they are learning a new representation and how this will be used in the future.
	1	A relationship to molecule conformation (NP) or stereochemistry (FP) is implied or explicitly stated	Introduction to diagrams is found in the chapter on "Conformation," or is explicitly related to conformation	Introduction to diagrams is found in the chapter on "Stereochemistry", or is described within discussions of three-dimensionality of chiral centers	
Definitions of representation-specific conventions	0	Conventions of the representation are not defined	No discussion of what the lines and circles in the diagram represent or how the lines/circles are organized	No discussion of what the lines in the diagram represent	*Principle 1:* Diagrams are a form of communication in chemistry. Therefore, a thorough understanding of the conventions of diagrammatic representations used in the discipline is critical, and novices should be explicitly introduced to these conventions.
	1	Definitions are given, but may not be fully developed	The circle in the diagram is presented as representing the back carbon itself	Horizontal lines are discussed as representing bonds that come out of the page, or are projected toward the viewer, and vertical lines represent bonds that are going into the page, or away from the viewer	
	2	Complete definitions are given	The circle in the diagram is presented as representing the electron density around the carbon-carbon bond	N/A	
Relationship to other chemical representations					
Relationship to the dash-wedge diagram (DW)	0	DWs are not referenced when introducing NPs or FPs	DW diagrams are not referred to in the text, nor are they used in illustrations when introducing the NP	DW diagrams are not referred to in the text, nor are they used in illustrations when introducing the FP	*Principles 1 & 2:* Multiple representations can be used to depict the same molecule. *Principle 3:* The NP must be related to the "end-on" view of a molecule, and the FP to the eclipsed conformation of a molecule. *Principle 4:* Text and illustrations should be utilized in conjunction to establish tacit connections between different diagrammatic forms
	1	A relationship between NPs or FPs and the DW is implied	DWs are used as an initial molecular representation in illustrations depicting a transformation to NPs, or DWs are referred to in the text but not in illustrations	DWs are used as an initial molecular representation in illustrations depicting a transformation to FPs, or DWs are referred to in the text but not in illustrations	
	2	The relationship is explicitly stated	The DW is referred to in the text, as well as in illustrations; e.g., relating the NP as a DW rotated 90^{o} towards the viewer	The DW is referred to in the text, as well as in illustrations; e.g., horizontal lines are related to the "wedges" in DW diagrams, and vertical lines are related to the "dashes" in the DW	

Table S1, Continued

Analysis Areas	Possible Scores		Description within NPs	Description within FPs	Rationale & Alignment to Principles
Introduction of the Projection, Continued					
Relationship to other chemical representations, continued					
Relationship to 3D representations	0	See Descriptions	No 3D diagrams are used in the introduction of NPs	No 3D diagrams are used in the introduction of FPs	*Principle 1:* Both 2D and 3D representations can be utilized to depict the same molecule, whether represented as a DW, NP, or FP *Principle 5:* Making explicit connections between the 2D and 3D nature of molecules reduces cognitive load by removing the need to abstract 3D information from the 2D diagram
	1	The textbook explicitly illustrates the 2D-3D relationship of the NP or FP diagram	The text uses 3D representations, such as ball-and-stick models, to portray NPs and to illustrate how they are constructed/drawn	The text uses 3D representations, such as ball-and-stick models, to portray FPs and to illustrate how they are constructed/drawn	
Relationship to other 2D representations	0	See Descriptions	No other 2D chemical diagrams, or only DWs, are used in the introduction of NPs	No other 2D chemical diagrams, or only DWs, are used in the introduction of FPs	*Principle 1:* Multiple 2D representations of molecules exist aside from the commonly used DW, NP, and FP *Principle 2:* Molecules are dynamic entities that can rotate and adopt multiple conformations. The DW, FP, and NP can each be used in unique ways to represent these different conformations.
	1	The textbook relates the NP or FP to other 2D diagrams aside from the DW	The text uses other representations, such as saw-horse projections, to portray NPs and to illustrate how they are constructed/drawn	The text uses other representations, such as NPs, to portray FPs and to illustrate how they are constructed/drawn	
Construction of the projection					
Stepwise Construction	0	No stepwise approach is used	Construction of the NP is presented as a one-step process	Construction of the FP is presented as a one-step process	*Principle 5:* There are many critical details that must be addressed when diagramming 2D and 3D molecules and a step-wise process reduces cognitive load by simplifying this process.
	1	A stepwise approach to construction of diagrams is used	Construction of the NP is presented as a series of steps necessary to create the representation in its entirety	Construction of the FP is presented as a series of steps necessary to create the representation in its entirety	
Diagrammatic and text-based examples	0	Text and illustrations stand alone	Text and illustrations do not relate to one another	Text and illustrations do not relate to one another	*Principle 4:* Novices benefit most when new material is presented in both written and illustrated formats. This allows the user to cement their understanding of the diagram conventions.
	1	Text and illustrations are used in conjunction	Text clearly describes illustrations and illustrations clearly reference the instructions given in the text	Text clearly describes illustrations and illustrations clearly reference the instructions given in the text	

Table S1, Continued

Analysis Areas	Possible Scores		Description within NPs	Description within FPs	Rationale & Alignment to Principles
Construction of the Projection, Continued					
Molecule conformation					
Discussion of molecular conformation with respect to representations	0	The text does not address conformation of molecules	At the point of introduction to the NP, the text does not differentiate between NPs of eclipsed and staggered molecules	The text does not state that FPs can be formed from the eclipsed conformation only	*Principles 2-5:* Explicit discussion of substituent relationships allows the user to understand how a diagram should be interpreted and "read" for chemical information. With FPs, it is vital that novices understand the conventions of the diagram, and that these representations can only be created for molecules in the eclipsed conformations.
	1	Text or illustrations show the importance of molecule conformation	The text states or illustrations imply that staggered molecules are drawn with 60^{o} between front and back substituents, and eclipsed conformations are shown with substituents slightly offset	The book states in the text or implies within illustrations the necessity of the eclipsed conformation prior to creating the FP	
	2	Text and illustrations are used to show importance of molecule conformation	The book states both in text and within illustrations the connection between substituent angles and conformations	The book states both in text and within illustrations the importance of using the eclipsed conformation when creating FPs	
Illustrations and compound conformation	0	Illustrations imply importance of molecule conformation in creating diagrams	Illustrations showing the translation of DWs to NPs present the DW in only one conformation or do not address how the conformation of the NP changes as a result of the DW being in either an eclipsed or staggered conformation	Illustrations consistently depict the initial DW representation in an eclipsed conformation prior to FP construction, or only single-carbon-center molecules are shown in illustrations	
	1	Illustrations depict representations of molecules in both staggered and eclipsed conformations	Illustrations showing the translation of both eclipsed and staggered molecules to NPs are shown, indicating the important modifications to the NP that occur as a result	Illustrations display the necessary rotation of a staggered molecule into the eclipsed conformation prior to creating the FP	
Viewing perspective					
Text discussion of viewing perspective	0	Multiple viewing perspectives are not discussed in the text	The text does not state that multiple viewing perspectives may be used	No mention of viewing perspective is discussed in the text	*Principle 3:* NPs can be viewed from multiple perspectives and still be considered correct while FPs can only be viewed in the eclipsed format, with the substituents pointing toward the viewer; it is vital that novices be told this explicitly.
	1	Viewing perspective is discussed explicitly in the text	The text explicitly states that the NP can be made by viewing the initial representation from both the left and the right (only if the original molecule is represented as a DW)	The text explicitly states that the initial representation must be viewed so that the substituents in the molecule point *toward* the viewer and the backbone points away from the viewer	

Table S1, Continued

Analysis Areas	Possible Scores		Description within NPs	Description within FPs	Rationale & Alignment to Principles
Construction of the Projection, Continued					
Viewing perspective, continued					
Directionality of viewing perspectives depicted in illustrations	0	Illustrations imply only one viewing perspective	Illustrations use only one viewing direction, or the viewing direction cannot be determined due to the use of symmetric molecules	Illustrations consistently show the viewing perspective from only one direction, the bottom or left of the originally presented molecule, for example; the viewing direction cannot be determined due to the use of symmetric molecules	*Principle 3:* Multiple viewing perspective are used as referents for constructing new diagrams. *Principle 4:* When used in conjunction with text, illustrations can reify students' understanding of representations.
	1	Illustrations display the NP or FP from multiple viewing perspectives	Illustrations display possible perspectives from both the left and right of the original molecule (if the original molecule is a DW)	Illustrations display possible perspectives from multiple directions	
Viewing perspective of initial diagram and relationship of substituents	0	Illustrations do not indicate a viewing perspective of the initial molecular representation	Illustrations include no perspective cue or the original molecule is not rotated towards the reader, and so the relationship of substituents as it relates to the reader's perspective is not indicated.	Illustrations that show a translation from DW (or ball & stick) representation to FP do not show a viewing perspective that the reader should take, such as an eye or stick person, and no relationship between the viewer and the substituent positions is implied	*Principle 3:* Illustrative cues are vital for novices attempting to understand how viewing perspective and directionality influence how representations are constructed.
	1	Illustrations explicitly indicate the direction of the viewing perspective and the resulting relationships of the substituents	Illustration cues are used to indicate a viewing perspective, OR the original molecule is rotated toward the reader, indicating the positions of the substituents in relation to the viewer's perspective	Illustrations include an eye or stick person, for example, to indicate the viewer's perspective; OR a DW diagram is presented as pointing "outward" to the readers' perspective, thus implying the positional relationships of reader and substituents	
	2	Illustrations indicate a viewing perspective and the resulting observer's view from this perspective	Illustrations include both a visual cue of viewing perspective on a given diagram (DW or ball & stick, for example) AND an image of this diagram from that perspective (such as a saw-horse representation)	Illustrations include both a visual cue of viewing perspective on a given diagram (e.g., DW or ball & stick) AND an image of this diagram from that perspective (such as the bowtie representation of the DW)	

Table S1, Continued

Analysis Areas	Possible Scores		Description within NPs	Description within FPs	Rationale & Alignment to Principles
Construction of the Projection, Continued					
Carbon centers and diagram construction	0	See descriptions	Only molecules with non-chiral centers are used	Only single-carbon-center molecules are used and these molecules are non-chiral	*Principle 3:* NP translations shown without using chiral centers lead to ambiguity regarding the viewing direction. Use of single-carbon-centered molecules in FPs deemphasizes the importance of the eclipsed conformation.
	1	See descriptions	Only molecules with one chiral center, with 4 different substituents on a carbon, are used	Only single-carbon-center molecules are used, but these molecules are chiral	
	2	See descriptions	Molecules with two chiral centers, with 4 different substituents on each carbon, are used	If multi-carbon-center molecules are used in illustrations, none or only one is chiral	
	3	See descriptions	N/A	Multi-carbon-center molecules are used in illustrations and each are chiral	
Representations Throughout the Text					
FPs in discussion of carbohydrates	0	No FPs in discussion	N/A	FPs are not used in the discussion of carbohydrate and sugar stereochemistry	*Principles 3 & 5:* Students are encouraged to establish referential connections between FPs and sugar and carbohydrate stereochemistry. More importantly, understanding FPs facilitates understanding of differences at chiral centers in sugars and carbohydrates (e.g., D vs. L sugars).
	1	FPs used in discussion	N/A	FPs are used in the discussion of carbohydrate and sugar stereochemistry	
FPs in discussion of R/S Configuration	0	No FPs in discussion	N/A	FPs not used in the discussion and introduction to R/S configurations of chiral carbons	*Principle 5:* FPs allow the user to "see" multiple chiral centers more readily and therefore identify their spatial relationships and configurations more easily.
	1	FPs used in discussion	N/A	FPs are used to discuss R/S configurations of chiral centers	
Viewing perspectives throughout the text	0	A variety of viewing perspectives is not used	Less than 40%, or greater than 60% of NPs depict a left viewing perspective, or the resulting NP is the same from either direction	Implied viewing perspectives from eclipsed molecules to FPs are from the same direction less in than 40% or greater than 60% of examples	*Principle 3:* The use of multiple viewing perspectives allows students to better relate DWs, NPs, and FPs of various conformations to each other.
	1	A variety of viewing perspectives is used	Only 40-60% of viewing perspective shown of NPs use the left viewing perspective	Implied viewing perspectives of eclipsed molecules are evenly distributed between directions	

Table S1, Continued

Analysis Areas	Possible Scores		Description within NPs	Description within FPs	Rationale & Alignment to Principles
Representations Throughout the Text, Continued					
Use of NPs in E2 Reactions	0	NPs are not used in E2 reactions	NPs are not used in the discussion and introduction to E2 reactions	N/A	*Principle 5:* Use of the NP to pictorially represent the spatial relationship between leaving group and nucleophile is critical for understanding the processes involved in E2 reactions. Possessing a strong understanding of the NP would therefore reduce cognitive load.
	1	NPs are used in E2 reactions	NPs are used in the introduction to the E2 reactions to introduce anti/syn-periplanar configurations	N/A	
Rotations throughout the text					
Illustration of rotations	0	Rotation of NPs is not shown	No illustration of the rotation around the carbon-carbon bond is included in the textbook	N/A	*Principle 2:* It is important that novices understand that molecules are dynamic and, therefore, can rotate and adopt many conformations. However, it is likewise important that students be made aware that not all rotational movement results in the formation of the same conformer and may, instead, result in isomers with different chemical properties.
	1	One carbon rotation	In illustrations, one carbon is shown as static, while the other can rotate	N/A	
	2	Two carbon rotation	An illustration depicts that both carbons can rotate independently of one another	N/A	
Textual discussion of rotations	0	No discussion of rotation	The text includes no discussion about the rotation around the carbon-carbon bond of a molecule	No discussion of the rules of FP rotation	
	1	Some discussion of rotation	A discussion of rotation around the carbon-carbon bond is included, but is vague as to how this rotation occurs (one carbon or two)	A discussion of the FP rotation rules is included, including that FPs must not be rotated 90^{o} as this changes the implied stereochemistry of the molecule, while a rotation of 180^{o} is permissible	
	2	Complete discussion of rotation	The text explicitly states that both carbon atoms can rotate independently of one another	N/A	

Table S2

Rubric for evaluation of practice of projection construction

Analysis Areas	Possible Scores		Description within NPs	Description within FPs	Rationale
Practice problems	0	No practice problems	Text does not include practice problems dealing with the construction of NPs	Text does not include practice problems dealing with the construction of FPs	It is important for students to practice translating between different representations if they are to develop metarepresentational competence.
	1	Practice problems included	Text includes practice problems dealing with NP construction	Text includes practice problems dealing with FP construction	
Viewing perspective(s) in practice					
Required or implied viewing perspectives and directionality	0	No viewing perspective provided	Practice problems do not ask the student to use a specific viewing perspective	Molecular representations are shown only in an eclipsed conformation, suggesting a single viewing perspective, or only single-centered molecules are used	Translating DW representations to NPs result in only one correct answer IF a viewing perspective is required. Not specifying a viewing direction can lead to ambiguity and confusion as to how to construct the NP properly. With FPs, it is vital that the student learns to put the molecule in the eclipsed formation, and approach this from the appropriate position relative to the substituents.
	1	Specific viewing perspective provided	Students are asked to use a specific viewing perspective in the construction of a NP	Practice problems do not provide a DW or ball & stick representation of the original molecule, only a name or molecular formula, or DWs are depicted in a staggered conformation; each of which result in no specific viewing perspective or directionality	
Variation of viewing perspective	0	Skewed number of viewing perspectives	If score of "1" above: Less than 40%, or greater than 60%, of viewing perspectives requested were from the left, or the resulting NP is the same when constructed from either viewing direction	If score of "0" above: Less than 40%, or greater than 60%, of implied viewing perspectives were from only one direction, such as the bottom of the DW molecule	It is important that students should have an opportunity to translate between representations using multiple viewing perspectives. This addresses the misconception that only a single viewing perspective is "correct."
	1	Even number of viewing perspectives requested	If score of "1" above: Only 40-60% of the requested viewing perspectives are from the left	If score of "0" above: Only 40-60% of implied viewing perspectives were from one direction	
Viewing perspective and nomenclature	0	No relationship between viewing perspective and nomenclature	Requested viewing perspectives do not correspond to nomenclature of the molecule, or no viewing directions were specifically requested	Directions do not require FPs to have the first priority carbon at the top of the vertical bond	Requiring alignment with molecular nomenclature again leads to only one correct answer for each problem, allows students to relate this information to previously acquired knowledge, and continues to align students to the common conventions associated with the diagrams.
	1	Viewing perspective corresponds to nomenclature	Requested viewing perspectives correspond to the nomenclature of the molecule	Directions indicate that FPs should be composed according to nomenclature, with the first priority substituent at the top of the FP	

Table S2, Continued

Analysis Areas	Possible Scores		Description within NPs	Description within FPs	Rationale
Molecule conformations and diagram frameworks	0	Basic framework of the diagram is given in practice problems	The basic circle and lines of the NP are provided in a synonymous conformation as that of the initial representation, and students are only required to fill in substituents in appropriate positions	Practice problems include molecules in only one conformer; if eclipsed, students do not have to rotate the molecule prior to fitting to the FP framework	The framework indicates the spatial relationships of the substituents on neighboring carbons of the original molecule. It is important for students be able to identify this framework on their own with NPs and rotate molecules accordingly to fit the framework of the FP as they scaffold their knowledge of the 3D relationships of molecules.
	1	Student construction of the diagram is required	Students must draw the front and back carbon substituents and the conformation of the diagram on their own, thus having to distinguish between eclipsed or staggered conformations of the NPs	Practice problems include initial representations of both eclipsed and staggered molecules to be translated into FPs, requiring students to master conventions of the FP	
Reverse construction	0	Practice problems include only transformations from DW to NPs or FPs	Students are only asked to transform DW diagrams to NPs, not the reverse	Students are only asked to transform DW diagrams to FPs, not the reverse	Metarepresentational competence can be developed, in part, by a more thorough understanding of the relationship between representations, which can be accentuated through practice in translating between the DW, NP, and FP
	1	Practice problems include reverse translations to DW	Problems asking students to translate NPs to DWs are included in the practice problem section	Problems asking students to translate FPs to DWs are included in the practice problem section	
Carbon centers in translation and construction tasks	0	See descriptions	In translation and construction tasks, only molecules with non-chiral centers are used	Only molecules with one non-chiral carbon center are used	With NPs, the use of chiral centers in practice problems creates specific locations of substituents in the "correct" answer that would not be apparent if all substituents were the same FPs are intended to allow users to see multiple chiral centers quickly and easily; students need practice with such molecules.
	1	See descriptions	In translation and construction tasks, molecules with one chiral center are used	Only single-carbon-center molecules are used, but these molecules are chiral	
	2	See descriptions	In translation and construction tasks, molecules with two chiral centers are used	If multi-carbon-center molecules are used in illustrations, none or only one is chiral	
	3	See descriptions	N/A	Multi-carbon-center molecules are used in illustrations and each are chiral	
Real-world applications of representations	0	See descriptions	Students are not asked to use NPs in determining the lowest and/or highest energy configurations of molecules	Students are not asked to use FPs when finding chiral center configurations in practice problems	These representations have multiple applications that are commonly introduced concurrently with the projections themselves. Providing students with an opportunity to understand how these representations are used in the real world is critical.
	1	See descriptions	Practice problems include NPs for students to use in determining the lowest and/or highest energy configurations of molecules	Practice problems give students FPs to use in finding chiral center configurations	
	2	See descriptions	Practice problems require students to create NPs in the process of determining the lowest and/or highest energy configurations	Practice problems require students to create FPs in the process of finding chiral center configurations	

Table S3
Evaluations of textbook introductions to Newman projections

	Bruice	Carey & Giuliano	Klein[a]	Klein[b]	Loudon	McMurry	Wade
Introduction to the Newman Projection (7)							
Purpose	1	1	1	1	1	1	1
Definition of representation-specific symbols	1	1	1	1	1	1	1
Relationship to other chemical representations							
Relationship to dash-wedge diagram	1	1	2	2	1	0	1
Relationship to 3D representations	0	1	0	0	1	1	0
Relationship to other 2D representations	0	1	1	0	0	1	1
Construction of the Newman Projection (11)							
Stepwise Construction	0	0	1	1	1	0	0
Diagrammatic and text-based examples	1	1	1	1	1	1	1
Molecule Conformation							
Discussion of molecule conformation with respect to representations	1	1	1	1	2	1	2
Illustrations and compound conformation	1	1	0	0	0	1	1
Viewing perspective							
Text discussion of viewing perspective	0	0	0	0	1	0	0
Directionality of viewing perspectives in illustrations	0	0	0	0	0	0	0
Viewing perspective of initial diagram and relationship of substituents	0	1	2	1	2	1	1
Carbon centers and diagram construction	0	0	2	0	0	0	0

Table S3, continued

Representations Throughout the Text (6)							
Viewing perspectives throughout the text	c	0	0	0	0	0	0
Use of NPs in E2 reactions	0	0	1	1	0	1	1
Rotations throughout the text							
Illustrations of NP rotations	2	0	2	1	1	1	1
Textual discussion of rotations	1	1	1	2	2	1	2
Total (24)	9	10	16	12	14	11	13

Note:

a: Organic Chemistry, 2012

b: Organic Chemistry as a Second Language, 2006 & 2008

c: One or fewer NP translations was illustrated in the later textbook sections that were reviewed

Table S4
Evaluations of textbook practice problems of Newman projections

	Bruice	Carey & Giuliano	Klein[a]	Klein[b]	Loudon	McMurry	Wade
Practice problems	1	1	1	1	1	1	1
Viewing perspective at practice							
Required or implied viewing perspectives and directionality	1	0	1	1	1	0	1
Variation of viewing perspective	c	d	0	0	c	d	c
Viewing perspective and nomenclature	1	1	1	1	1	1	1
Molecule conformation and diagram frameworks	1	1	1	1	1	1	1
Reverse construction	0	0	1	0	1	0	0
Carbon centers in translation and construction tasks	0	0	1	0	0	0	0
Real-world applications of representations	1	2	1	1	2	1	2
Total (10)	5	5	7	5	7	4	6

Notes:
a: Organic Chemistry, 2012
b: Organic Chemistry as a Second Language, 2006 & 2008
c: No translation tasks were included in the book. Construction tasks were from name or molecular formula only, and so no viewing perspective could be identified
d: Translation practice problems did not ask for specific viewing perspectives

Table S5
Evaluations of textbook introductions to Fischer projections

	Bruice	Carey & Giuliano	Klein[a]	Klein[b]	Loudon	McMurry	Wade
Introduction to the Fischer Projection (6)							
Purpose	1	1	1	1	1	1	1
Definition of representation-specific symbols	1	1	1	1	1	1	1
Relationship to other chemical representations							
Relationship to dash-wedge diagram	1	1	2	2	1	1	2
Relationship to 3D representations	0	1	0	0	0	1	1
Relationship to other representations	0	0	0	0	0	0	0
Construction of the Fischer Projection (12)							
Stepwise Construction	0	0	0	1	1	0	0
Diagrammatic and text-based examples	0	1	1	1	1	1	1
Molecule Conformation							
Discussion of molecule conformation with respect to representations	0	1	0	0	2	1	0
Illustrations and compound conformation	0	1	0	1	0	0	0
Viewing perspective							
Text discussion of viewing perspective	1	1	0	1	1	0	1
Directionality of viewing perspectives in illustrations	0	0	0	0	1	1	0
Viewing perspective of initial diagram and relationship of substituents	0	1	0	2	2	2	2
Carbon centers and diagram construction	1	3	3	3	3	1	1

Table S5, continued

Representations Throughout the Text (4)							
FPs in discussion of carbohydrates	1	1	1	c	1	1	1
FPs in discussion of R/S configurations	1	1	1	1	1	1	1
Viewing perspectives throughout the text	d	0	d	d	d	e	d
Rotations throughout the text							
Textual discussion of rotations	1	0	0	0	1	1	1
Total (22)	8	14	10	14	17	13	13

Notes:

a: Organic Chemistry, 2012

b: Organic Chemistry as a Second Language, 2006 & 2008

c: Textbook did not include a carbohydrate section

d: One or fewer FP translations was illustrated in the later textbook sections that were reviewed

e: FPs were introduced within the sugars chapter, and so does not fit with "Representations Throughout the Text"

Table S6
Evaluations of textbook practice problems of Fischer projections

	Bruice	Carey & Giuliano	Klein[a]	Klein[b]	Loudon	McMurry	Wade
Practice problems	1	1	1	0	1	1	1
Viewing perspective at practice							
Required or implied viewing perspectives and directionality	1[d]	1[d]	1[e]	c	1[d]	1[d,e]	1[d,e]
Variation of viewing perspective	f	f	f	c	f	f	f
Viewing perspective and nomenclature	0	0	0	c	0	0	0
Molecule conformation and diagram frameworks	d	d	0	c	d	1	1
Reverse construction	0	0	1	0	0	1	1
Carbon centers in translation and construction tasks	3	3	2	c	3	2	3
Real-world applications of representations	1	1	1	1	1	2	1
Total (11)	6	6	6	1	6	8	8

Note:
a: Organic Chemistry, 2012
b: Organic Chemistry as a Second Language, 2006 & 2008
c: No practice problems in FP construction were included in this textbook, therefore no further scores regarding such problems are included
d: Construction tasks were from name or molecular formula only, so no viewing perspective could be identified or framework employed
e: Practice problems provided staggered molecules from which to translate to FPS
f: Practice problems did not imply specific viewing perspective