Exploring Electronic Substituent Effects
a case comparison and inductive approach for meaningful learning
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Problem and Objectives

Problem
– electronic substituent effects are an ubiquitous and overarching concept of organic chemistry
– meaningful understanding obligatory to predict structural features’ impact on various mechanisms
– students often rely on deficient strategies instead

Objectives
– provide an integrated learning environment, that
  – facilitates access to the deep structure of electronic substituent effects
  – fosters transferable, concept-based explanations and meaningful understanding

Target Group
– pre-service secondary school teachers

Conceptual Design

State of Research
– studies reveal students’ deficits
  – focus on isolated structural features
  – application of single, context-bound models
  – reliance on shortcut heuristics

Technical Basis
– Hammett’s research from the 1930s onwards
  – correlation of structure and reactivity
  – quantification of electronic substituent effects
  – alkaline ester hydrolysis enables systematic monitoring of substituents’ impact on reaction rate
– opens up innovative context for exploring electronic substituent effects in organic chemistry education

Explanation Prompt (Inductive Process)

– cognitive dissonance (inductive process)

Intervention
Objectives
– part of teachers’ education organic laboratory class
– observation task applying guided-inquiry competitive experiments
– three-tier explorative assessment (n = 16) including
  – post-test (instruction quality, content knowledge)
  – explanation task applying laboratory protocols
  – with ICC instruction (treatment group, n = 8)
  – with standard instruction (control group, n = 8)

Evaluation
– good comprehension of instructional material
– similar recognition, but increased correct application of concepts and presence of structure- and energy-related explanations in treatment group
– two cases reveal access to the deep structure of electronic substituent effects in treatment group
– slightly higher improvement of treatment group’s content knowledge and explanation quality from post- to follow-up test

Evaluation
– Goodwin’s model of explanation in organic chemistry
– supports structured investigation and consistent explanation in accordance with Goodwin’s model
– adaptable to different deductive and inductive instructional strategies

Educational Basis
– Ausubel’s theory of meaningful learning as construction and reconstruction of knowledge structures
– Goodwin’s model of explanation in organic chemistry

Educational Concept
– utilizes inventing with contrasting cases (ICC)
  – contrasting cases cover broad range of effects
  – variation of one distinctive structural feature per case set focus on substituents’ impact
– supports structured investigation and consistent explanation in accordance with Goodwin’s model

The Learning Environment

Reaction Mechanism

Observation Step
– experiment/data-based testing of invented explanations (deductive process)
– observation prompt and induction of cognitive dissonance (inductive process)

Comparison Step
– model-based investigation of structural information
– identification of differences and commonalities across cases

Introduction and Evaluation

Implementation
– into lectures and review seminars (including investigation of prepared data)
– into laboratory classes (including investigation of experimentally collected data)

Further Evaluation
– more detailed investigation of concept-based reasoning and meaningful understanding applying
  – interview studies and qualitative content analysis
  – concept mapping

Prospects

Enhancement
– additional contrasting cases providing access to concepts of position dependency and steric hindrance

References


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